The Life of a Cell

Unit Overview

Unit 3 introduces students to basic chemistry, the structure and function of cells, and cell energetics. In Chapter 6, students learn the basic concepts of chemistry that are important in biology. Chapter 7 introduces cell structure and function of organelles. This discussion is expanded upon in Chapter 8 through an in-depth view of cellular transport and the cell cycle. Finally, Chapter 9 acquaints students with the details of energy flow that result from photosynthesis and respiration.

Introducing the Unit

Ask students to describe some of the things they see in the photograph of cells of the retina in terms of color, shape, and other visual characteristics. We appreciate the amazing variety and details of the visual world around us through the work of specialized cells in the retina. Each retinal cell receives a small piece of an image from another cell, such as the pyramidal neuron from another part of the brain, and only by working together can cells piece together all of the information to give an accurate view of the world around us.

Unit 3

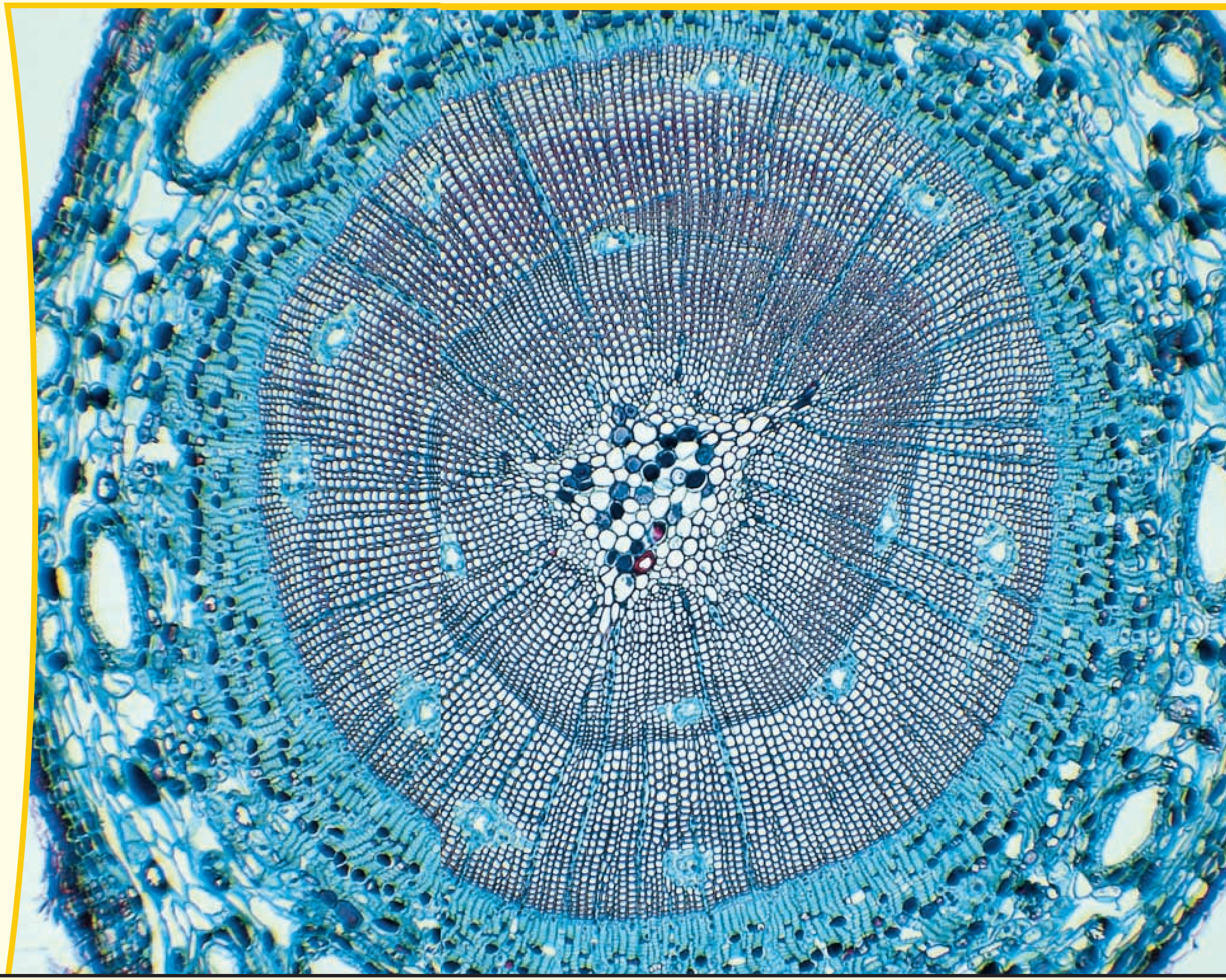
The Life of a Cell

A cell is the most basic unit of living organisms. No matter how complex an organism becomes, at its core is a collection of cells. As a cell grows in size, it eventually divides to form two identical cells. In many organisms, cells work together, forming more complex structures.

Unit Contents

Unit Project

internet CONNECTION Use the Glencoe Science Web Site for more project activities that are connected to this unit. www.glencoe.com/sec/science



Unit 3

Advance Planning

Chapter 6

- Obtain potassium peranganate for the BioLab, mint oil for the Activity on p. 160, and ball-and-stick models for the Quick Demo and Revealing Misconceptions.

Chapter 7

- Purchase prepared slides for Microscopy project, Portfolio activity, and BioLab.
- Purchase animal and plant cell models and an *Elodea* plant.

Chapter 8

- Schedule guest speakers (cell biologist and school nurse).
- Order prepared frog blastula slides for MiniLab and onion root slides for BioLab.

Chapter 9

- Obtain filter paper for the chromatography project.
- Purchase a molecular model of a lipid and dialysis bags for the BioDigest activities.

Unit Projects

Develop a Model of a Cell

Have students do one of the projects for this unit as described on the Glencoe Science Web Site. As an alternative, students can do one of the projects described on these two pages.

Display

Visual-Spatial Instruct students to collect examples of cells from magazines and science journals. They should make a display that describes the different parts of a cell. L1 ELL

Building a Model

Kinesthetic Have student groups design and make a model of a cell that they might find in any part of a plant. They may use any materials they wish. Small motors can be used to show the motion of cell products. L1 ELL

Unit Projects

Using the Library

Intrapersonal Encourage students to find out how a cell uses energy and make a poster showing the flow of energy through a cell. L2

Microscopy

Visual-Spatial Have students examine slides of different types of human cells (muscle, nerve, skin, etc.). They can draw diagrams of each and postulate why each has its unique shape. L1 ELL

Final Report

Have student groups compile their findings about cells in reports that could be presented to students at your local middle school. L3

Refer to pages 4T-5T of the Teacher Guide for an explanation of the National Science Education Standards correlations.

Section	Objectives	Activities/Features
Section 6.1 **Atoms and Their Interactions** National Science Education Standards UCP.1, UCP.2, UCP.3; A.1, A.2; B.1-3; C.5; D.2; E.1, E.2; F.1; G.1, G.2 (1 session, 1/2 block)	1. **Relate** the particle structure of an atom to the identity of elements. 2. **Relate** the formation of covalent and ionic chemical bonds to the stability of atoms. 3. **Distinguish** mixtures and solutions. 4. **Define** acids and bases and relate their importance to biological systems.	**Problem-Solving Lab 6-1,** p. 149 **Careers in Biology:** Weed/Pest Control Technician, p. 154 **MiniLab 6-1:** Determine pH, p. 155 **Design Your Own BioLab:** Does temperature affect an enzyme reaction? p. 168
Section 6.2 **Water and Diffusion** National Science Education Standards UCP.2, UCP.3, UCP.4; A.1, A.2; C.5; G.1, G.3 (1 session, 1/2 block)	5. **Relate** water's unique features to polarity. 6. **Explain** how the process of diffusion occurs and why it is important to cells.	**Problem-Solving Lab 6-2,** p. 158 **MiniLab 6-2:** Examine the Rate of Diffusion, p. 159
Section 6.3 **Life Substances** National Science Education Standards UCP.1, UCP.2; A.1, A.2; B.2, B.3; C.5; E.1, E.2; G.1-3 (3 sessions, 1 block)	7. **Classify** the variety of organic compounds. 8. **Describe** how polymers are formed and broken down in organisms. 9. **Compare** the chemical structures of carbohydrates, lipids, proteins, and nucleic acids, and relate their importance to living things.	**Inside Story:** Action of Enzymes, p. 166 **BioTechnology:** Are fake fats for real? p. 170

Need Materials? Contact Carolina Biological Supply Company at 1-800-334-5551 or at **http://www.carolina.com**

MATERIALS LIST

BioLab

p. 168 timer or clock, 400-mL beaker, kitchen knife, tongs or forceps, potato, 3% hydrogen peroxide, ice, hot plate, waxed paper, thermometer

MiniLabs

p. 155 small beakers (4), lemon juice, household ammonia solution, liquid detergent, shampoo, vinegar, pH paper, pH color chart

p. 159 raw potato, single-edge razor blade, beaker, forceps, metric ruler, timer or clock, potassium permanganate solution

Alternative Lab

p. 164 paper cups (4), gelatin dessert mix, fresh pineapple, canned chunk pineapple, grapes or orange sections, refrigerator, waxed paper, knife, water

Quick Demos

p. 146 iron nails, copper pipe, aluminum foil, coal or charcoal, mercury thermometer

p. 150 beaker, water, table salt, 9-volt battery, electrical wire

p. 157 paper towel, bowl; cooking pot, Bunsen burner, ring stand

p. 163 model of methane molecule

Key to Teaching Strategies

- **L1** Level 1 activities should be appropriate for students with learning difficulties.
- **L2** Level 2 activities should be within the ability range of all students.
- **L3** Level 3 activities are designed for above-average students.
- **ELL** ELL activities should be within the ability range of English Language Learners.
- **COOP LEARN** Cooperative Learning activities are designed for small group work.
- **P** These strategies represent student products that can be placed into a best-work portfolio.
- (block icon) These strategies are useful in a block scheduling format.

Teacher Classroom Resources

Section	Reproducible Masters	Transparencies
Section 6.1 **Atoms and Their Interactions**	Reinforcement and Study Guide, pp. 25-26 L2 BioLab and MiniLab Worksheets, p. 27 L2 Content Mastery, pp. 29-30, 32 L1	Section Focus Transparency 12 L1 ELL Basic Concepts Transparency 4 L2 ELL Basic Concepts Transparency 5a, 5b L2 ELL
Section 6.2 **Water and Diffusion**	Reinforcement and Study Guide, p. 27 L2 Concept Mapping, p. 6 L3 ELL BioLab and MiniLab Worksheets, p. 28 L2 Content Mastery, pp. 29-32 L1	Section Focus Transparency 13 L1 ELL
Section 6.3 **Life Substances**	Reinforcement and Study Guide, p. 28 L2 Critical Thinking/Problem Solving, p. 6 L3 BioLab and MiniLab Worksheets, pp. 29-30 L2 Laboratory Manual, pp. 39-46 L2 Content Mastery, pp. 29, 31-32 L1 Tech Prep Applications, pp. 9-10 L2	Section Focus Transparency 14 L1 ELL Reteaching Skills Transparency 8 L1 ELL

Assessment Resources

Chapter Assessment, pp. 31-36
MindJogger Videoquizzes
Performance Assessment in the Biology Classroom
Alternate Assessment in the Science Classroom
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 6 quiz

Additional Resources

Spanish Resources ELL
English/Spanish Audiocassettes ELL
Cooperative Learning in the Science Classroom COOP LEARN
Lesson Plans/Block Scheduling

NATIONAL GEOGRAPHIC Teacher's Corner

Index to National Geographic Magazine

The following articles may be used for research relating to this chapter:

"Worlds Within the Atom," by John Boslough, May 1985.

GLENCOE TECHNOLOGY

The following multimedia resources are available from Glencoe.

Biology: The Dynamics of Life

CD-ROM ELL

Animation: *The Covalent Bond*
Animation: *The Ionic Bond*
Animation: *Enzyme Action*
Exploration: *Acid Base Test*
Video: *Properties of Water*

Videodisc Program

Covalent Bonding
Ionic Bonding
Properties of Water

The Infinite Voyage

Unseen Worlds
The Future of the Past

Getting Started Demo

Direct students' attention to the photographs shown here. Ask students to list the features of living things in their journals. Also ask students to speculate and write in their journals about why early scientists thought a mysterious force controlled chemical changes in organisms. L2

Theme Development

Unity within diversity is stressed through the discussion that although living things and nonliving things differ, they are alike in that all are made up of elements. **Energy** should be discussed along with chemical reactions. Be sure to stress that although elements unite with other matter or break apart during chemical reactions, matter is neither created nor destroyed.

0:00 Out of Time?

If time does not permit teaching the entire chapter, use the BioDigest at the end of the unit as an overview.

Chapter

6 The Chemistry of Life

What You'll Learn

- You will relate the structure of an atom to how it interacts with other atoms.
- You will explain how water is important to life.
- You will compare the role of carbon compounds in organisms.

Why It's Important

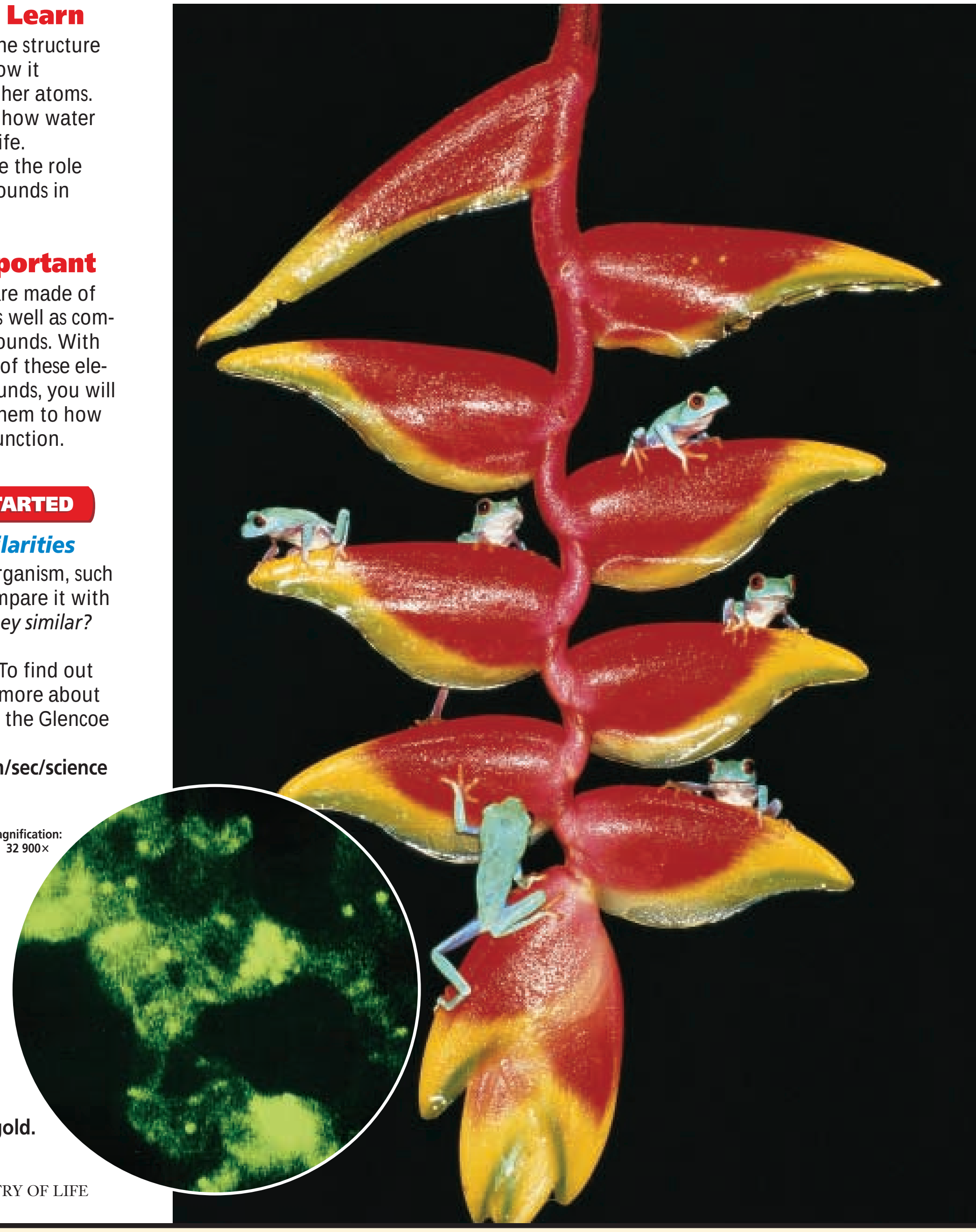
Living organisms are made of simple elements as well as complex carbon compounds. With an understanding of these elements and compounds, you will be able to relate them to how living organisms function.

Getting Started

Predicting Similarities

Observe a living organism, such as a plant, and compare it with a rock. *How are they similar?*

interNET CONNECTION To find out more about cell chemistry, visit the Glencoe Science Web Site. **www.glencoe.com/sec/science**



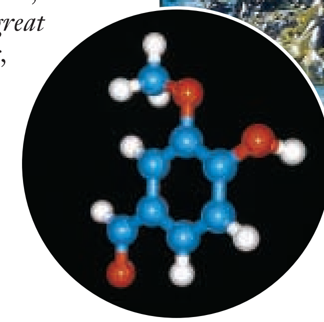
Magnification: 32 900×

The gold shown in this scanning-tunneling microscope picture is made of atoms. Atoms make up the colorful frogs and the element gold.

Section

6.1 Atoms and Their Interactions

What makes a living thing different from a nonliving thing? Are the particles that make up a rock different from those of a frog or a clam? The difference between living and nonliving things may be readily apparent to you. For example, you may have played a game of basketball yesterday, something you would not expect a rock to do. We know, however, that living things have a great deal in common with rocks, CDs, computer chips, and other nonliving objects. Both living and nonliving things are composed of the same basic building blocks called atoms.



All things are similar at the atomic level.

Section Preview

Objectives

Relate the particle structure of an atom to the identity of elements.

Relate the formation of covalent and ionic chemical bonds to the stability of atoms.

Distinguish mixtures and solutions.

Define acids and bases and relate their importance to biological systems.

Vocabulary

element
atom
nucleus
isotope
compound
covalent bond
molecule
ion
ionic bond
metabolism
mixture
solution
pH
acid
base

Elements

Everything—whether it is a rock, frog, or flower—is made of substances called elements. Suppose you find a nugget of pure gold. You could grind it into a billion bits of powder and every particle would still be gold. You could treat the gold with every known chemical, but you could never break it down into simpler substances. That's because gold is an element. An **element** is a substance that can't be broken down into simpler chemical substances. On Earth, 90 elements occur naturally.

Natural elements in living things

Of the 90 naturally occurring elements, only about 25 are essential to living organisms. ***Table 6.1*** lists some elements found in the human body. Notice that only four of the 90 elements—carbon, hydrogen, oxygen, and nitrogen—make up more than 96 percent of the mass of a human. Each element is identified by a one- or two-letter abbreviation called a symbol. For example, the symbol C represents the element carbon, Ca represents calcium, and Cl represents chlorine.

Prepare

Key Concepts

Students are introduced to the subatomic particles that make up the atoms of elements. In addition, students become acquainted with isotopes in biology. Students also study compounds and bonding. Students compare the properties of acids and bases.

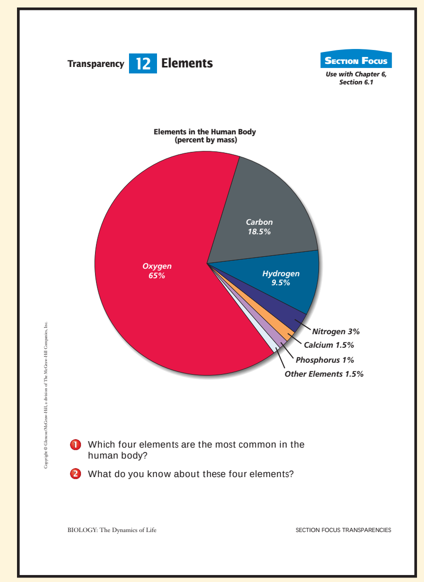
Planning

- Gather items for the Quick Demo and demonstrations.
- Purchase sand, salt, and gelatin for the Enrichment.
- Obtain common household solutions for MiniLab 6-1.
- Purchase beans and toothpicks and gumdrops or marshmallows for the activities.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 12** on the overhead projector and have students answer the accompanying questions. L1 ELL



Multiple Learning Styles

Look for the following logos for strategies that emphasize different learning modalities.

Kinesthetic Meeting Individual Needs, p. 147; Project, p. 151; Reteach, p. 153; Activity, p. 154

Visual-Spatial Portfolio, p. 146; Extension, p. 153; Biology Journal, pp. 157, 158; Reteach, p. 153; Tech Prep, p. 162; Check for Understanding, p. 166

Interpersonal Meeting Individual Needs, p. 161; Portfolio, p. 163

Intrapersonal Enrichment, pp. 148, 165; Portfolio, p. 153; Extension, p. 160;

Linguistic Biology Journal, pp. 149, 161; Portfolio, p. 159

Logical-Mathematical Quick Demo, p. 157; Activity, p. 160; Portfolio, p. 162; Going Further, p. 169

Assessment Planner

Portfolio Assessment
MiniLab, TWE, pp. 155, 159
BioLab, TWE, p. 169

Performance Assessment
MiniLabs, SE, pp. 155, 159
BioLab, SE, p. 169
Alternative Lab, TWE, p. 165

Knowledge Assessment
Assessment, TWE, pp. 147, 160, 162, 167

Problem-Solving Labs, TWE, pp. 149, 158
Alternative Lab, TWE, p. 165
Section Assessments, TWE, pp. 155, 160, 167
Chapter Assessment, TWE, p. 171-173

Skill Assessment
Assessment, TWE, p. 153

2 Teach

Quick Demo

Display various elements using common objects such as iron nails, a piece of copper pipe, a piece of aluminum foil, a piece of coal or charcoal, and a mercury thermometer. Tell students that each material is composed of a different kind of element. Direct students' attention to the appropriate object when discussing each element.

Visual Learning

Visual-Spatial Discuss possible dietary sources of each element listed in Table 6.1. Have students redesign the table to include pictures that show two sources of each element listed. Have students conduct additional research if necessary. L2 ELL

Concept Development

Stress that the elements carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur are the main components of living matter. All these elements form molecules through covalent bonding.

GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
Composition of Living Organisms

Table 6.1 Elements that make up the human body

Element	Symbol	Percent by mass in human body	Element	Symbol	Percent by mass in human body
Oxygen	O	65.0	Iron	Fe	trace
Carbon	C	18.5	Zinc	Zn	trace
Hydrogen	H	9.5	Copper	Cu	trace
Nitrogen	N	3.3	Iodine	I	trace
Calcium	Ca	1.5	Manganese	Mn	trace
Phosphorus	P	1.0	Boron	B	trace
Potassium	K	0.4	Chromium	Cr	trace
Sulfur	S	0.3	Molybdenum	Mo	trace
Sodium	Na	0.2	Cobalt	Co	trace
Chlorine	Cl	0.2	Selenium	Se	trace
Magnesium	Mg	0.1	Fluorine	F	trace

Trace elements

Notice that some of the elements listed in *Table 6.1*, such as iron and magnesium, are present in living things in very small amounts. Such elements are known as trace elements. They play a vital role in maintaining healthy cells in all organisms, as shown by the examples in *Figure 6.1*. Plants obtain trace elements by absorbing them through their roots. Animals get these important elements from the foods they eat.

Figure 6.1
Trace elements are needed in small amounts to control cell metabolism.

Atoms: The Building Blocks of Elements

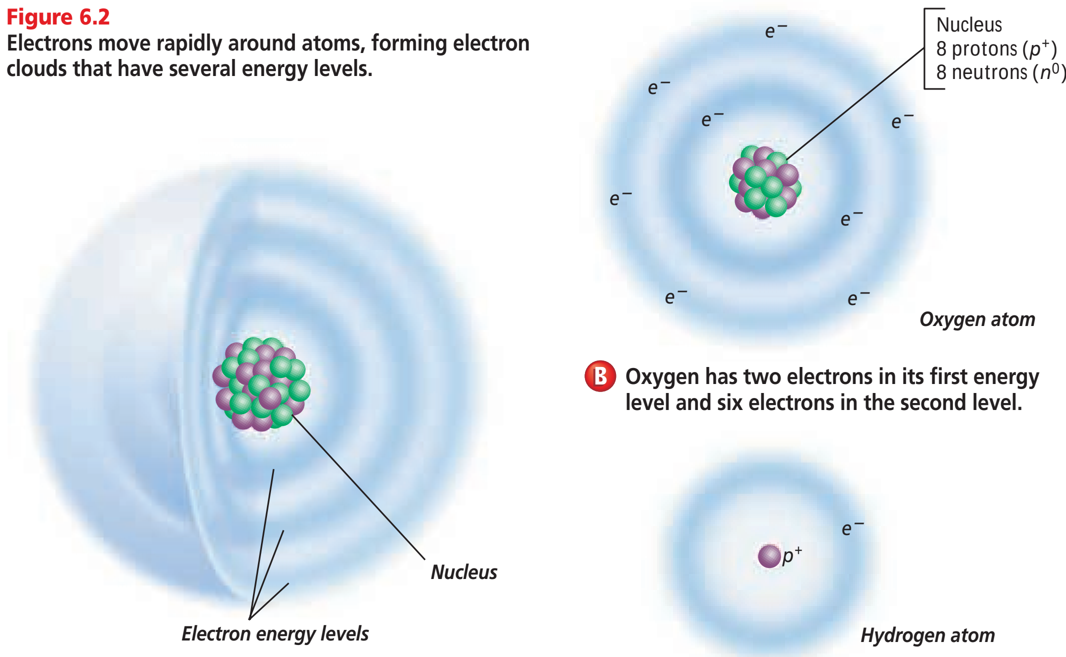
Elements, whether they are found in living things or not, are made up of atoms. An **atom** is the smallest particle of an element that has the characteristics of that element.

A Mammals use iodine (I), an essential element, to produce substances that affect the rates of growth, development, and chemical activities in the body.

B Plants must have magnesium (Mg) in order to form the green pigment chlorophyll that captures light energy for the production of sugars.

C A trace of fluorine, another essential element, binds with the surface structure of teeth, making them resistant to decay.

Figure 6.2
Electrons move rapidly around atoms, forming electron clouds that have several energy levels.



A An atom has a nucleus and electrons in cloudlike energy levels.

B Oxygen has two electrons in its first energy level and six electrons in the second level.

C Hydrogen, the simplest atom, has just one electron in its first energy level and one proton in its nucleus.

The structure of an atom

Each element has distinct characteristics that result from the structure of the atoms that compose the element. For example, iron differs from aluminum because the structure of iron atoms differs from that of aluminum atoms. Still, all atoms have the same general arrangement. The center of an atom is called the **nucleus** (NEW klee us) (plural, nuclei). It is made of positively charged particles called protons (p^+) and particles that have no charge, called neutrons (n^0). All nuclei are positively charged because of the presence of protons.

Forming a cloud around the nucleus are even smaller, negatively charged particles called electrons (e^-). If you've ever looked at a spinning fan, you've probably noticed that as the fan blades turn, they appear to form a blurry disk that occupies a space around the center of the fan. Similarly, an electron cloud is the space around the atom's nucleus that is occupied by these fast-moving electrons. Although it is impossible to pinpoint the exact location of an electron because it is moving so quickly, the electron cloud is an area where it is most likely to be found.

Electron energy levels

Electrons travel around the nucleus in certain regions known as energy levels, as indicated by *Figure 6.2*. Each energy level has a limited capacity for electrons. Because the first energy level is the smallest, it can hold a maximum of only two electrons. The second level is larger and can hold a maximum of eight electrons. The third level is larger yet and can hold 18 electrons. For example,

Tying to Previous Knowledge

Relate the discussion of the chemistry of life to the characteristics of living things discussed in Chapter 1. Emphasize that the presence of carbon is a characteristic shared by all organisms.

Display

Make a bulletin board display that models the structure of an atom. Label the nucleus, protons, neutrons, and electrons of the model. Refer to the display when discussing atomic structure.

Assessment

Knowledge On the chalkboard, prepare a table with the heads: Particle, Location, Charge, and Symbol. Beneath the Particle head, list: Electron, Neutron, and Proton. Have volunteers come to the chalkboard to complete the table. L2

GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
Hydrogen/Carbon Atom

Oxygen Atom

Portfolio

Diagramming Atomic Structure

Visual-Spatial Have students make a detailed drawing of an aluminum atom, showing the contents of the nucleus of the atom and the energy levels of the electrons. L3 ELL P

Resource Manager

Section Focus Transparency 12 and Master L1
Basic Concepts Transparency 4 and Master L2 ELL

MEETING INDIVIDUAL NEEDS

Visually Impaired

Kinesthetic To help students who are visually impaired understand the structure of an atom, make atomic models by gluing marbles, jelly beans, and yarn to a piece of cardboard. Use the yarn to outline the nucleus and the energy levels. Use marbles for the neutrons and jelly beans for the electrons and protons. Allow visually impaired students to manipulate the model. Have peers work with visually impaired students to assist in identifying the parts of the model. L1 ELL

Enrichment

Intrapersonal The scanning tunneling microscope (STM) provides a three-dimensional map of a molecule's surface by measuring the flow of electrons across a small vacuum gap. A tungsten tip similar to a phonograph needle is positioned a few angstroms from the substance being studied. When a small voltage is applied, some electrons jump across the gap between the tip and the surface. As the tip moves across the surface, the current varies according to the contours of the atoms present. Have capable students research these microscopes and give a presentation to the class. L3

Discussion

Radiation can penetrate and disrupt the functions of living cells. However, certain radioisotopes have practical uses in medicine as diagnostic tools. For example, radioactive iodine is used to identify problems with the thyroid gland. Lead a discussion on how the benefits of such radiation compare with the risks of exposure.

GLENCOE TECHNOLOGY

VIDEODISC
The Infinite Voyage
Unseen Worlds
Studying the Basic Building Blocks: The Atom (Ch. 9) 2 min.

The Scanning Tunneling Microscope: Observing Atomic Particles (Ch. 10) 2 min.

Figure 6.3
The properties of an element are determined by the structure of its atoms. As you can see, copper, gold, and carbon have very different properties.

the oxygen atom in ***Figure 6.2*** has a total of eight electrons. Two electrons fill the first energy level. The remaining six electrons occupy the second level.

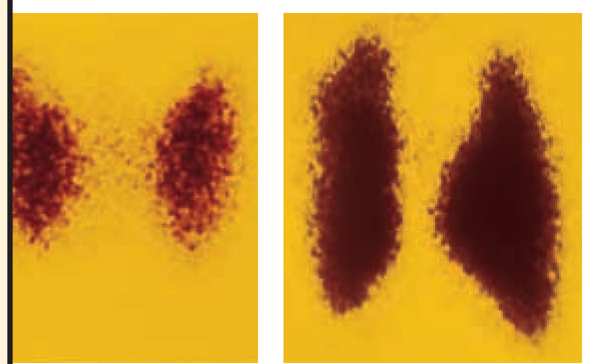
Atoms contain equal numbers of electrons and protons; therefore, they have no net charge. The hydrogen (H) atom in ***Figure 6.2*** has just one electron and one proton. Oxygen (O) has eight electrons and eight protons. ***Figure 6.3*** shows three other elements whose properties differ because of their atomic structure.

Isotopes of an Element

Atoms of an element sometimes contain different numbers of neutrons in the nucleus. Atoms of the same element that have different numbers of neutrons are called **isotopes** (I suh tohps) of that element. For example, most carbon nuclei contain six neutrons. However, some have seven or eight neutrons. Each of these atoms is an isotope of the element carbon. Scientists refer to isotopes by giving the combined total of protons and neutrons in the nucleus. Thus, the most common carbon atom is referred to as carbon-12 because it has six protons and six neutrons. Other isotopes of carbon include carbon-13 and carbon-14.

Isotopes are often useful to scientists. The nuclei of some isotopes, such as carbon-14, are unstable and tend to break apart. As nuclei break, they give off radiation. These isotopes are said to be radioactive. Because radiation is detectable and

Figure 6.4
Radioactive isotopes are used in medicine to diagnose and/or treat some diseases.



A **Radioactive iodine (I) introduced into the body is absorbed by the thyroid gland. By detecting the radioactive iodine taken up, the function of the thyroid gland can be measured. The thyroid scan on the left is normal and the scan on the right is overactive.**

B **Radiation given off when radioactive isotopes break apart is deadly to rapidly growing cancer cells. The patient is being treated with radiation from a radioactive isotope of cobalt (Co).**

can damage or kill cells, scientists have developed some useful applications for radioactive isotopes, as described in ***Figure 6.4.***

Atomic models like those discussed in the *Problem-Solving Lab* on this page help scientists and students visualize the structure of atoms and understand complex intermolecular interactions.

Compounds and Bonding

Water is a substance that everyone is familiar with; however, water is not an element. Rather, water is a type of substance called a compound. A **compound** is a substance that is composed of atoms of two or more different elements that are chemically combined. Water (H_2O) is a compound composed of the elements hydrogen and oxygen. If you pass an electric current through water, it breaks down into these elements. Just as the combined ingredients in a pizza result in a tasty meal, you can see in ***Figure 6.5*** that the properties of a compound are different from those of its individual elements.

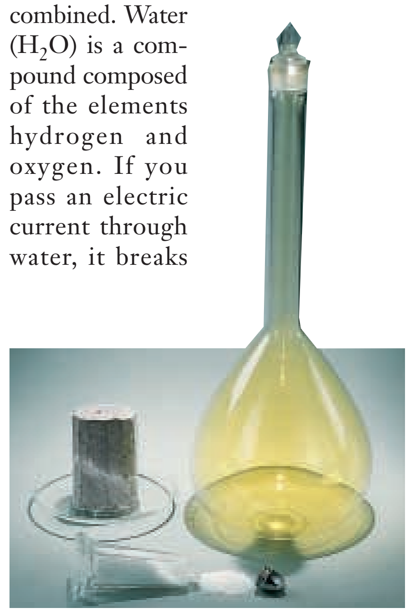


Figure 6.5
Table salt is made from the elements sodium (Na) and chlorine (Cl). The flask contains the poisonous, yellow-green chlorine gas. The lump of silver-white metal is the element sodium. The white crystals of table salt no longer resemble either sodium or chlorine.

How covalent bonds form

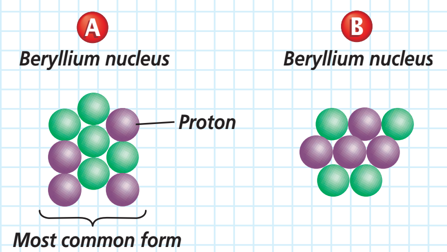
Most matter is in the form of compounds. But how and why do atoms combine, and what is it that holds the atoms of unlike components together in a compound? Atoms combine with other atoms only when conditions are right, and they do so to become more stable.

Problem-Solving Lab 6-1 — Interpreting Scientific Illustrations

What information can be gained from seeing the nucleus of an atom? Looking at a model of an atom's nucleus can reveal certain information about that particular atom. Models may help predict electron number, position of electrons in energy levels, and how isotopes of an element differ from each other.

Analysis

Examine diagrams A and B. Both are models of an atom of beryllium. Only the nucleus of each atom is shown.



Thinking Critically

1. What is the neutron number for A? For B?
2. Which diagram represents an isotope of beryllium? Explain how you were able to tell.
3. How many electrons are present in atoms A and B? Explain how you were able to tell.
4. How many energy levels would be present for A and B? How might the electrons in A and B be distributed in these levels?

Problem-Solving Lab 6-1

Purpose

Students will use diagrams of a nucleus of beryllium to predict electron number, position of electrons in energy shells, and how differences in the number of neutrons affects the element.

Process Skills

think critically, apply concepts, compare and contrast, define operationally, interpret data

Teaching Strategies

- Review the concept of isotopes with students. Provide other examples for them to analyze.
- Explain or emphasize the concept that all atoms of the same element have the same electron and proton number. They may differ only in the number of neutrons.
- Review the charges associated with each atomic particle.

Thinking Critically

1. 5, 4
2. Both A and B have four protons, so they are both isotopes of beryllium.
3. 4. Electron and proton numbers are always the same.
4. 2. Two electrons in each level.

Assessment

Knowledge Provide students with two diagrams of the nucleus for the element fluorine. Have one nucleus with 9 neutrons and one with 10 neutrons. Advise them of the most common form (with 9 neutrons). Ask them to provide the same information for beryllium. Use the Performance Task Assessment List for Making Observations and Inferences in **PASC**, p. 17. L2

Internet Address Book

internet CONNECTION Note Internet addresses that you find useful in the space below for quick reference.

Biology Journal

Life as an Atom

Linguistic Ask students to pretend that they are a particular type of atom. Ask them to write a paragraph or two describing their basic structure. Encourage the students to use their imaginations, while retaining scientific accuracy. L2

Resource Manager

Basic Concepts Transparency 5a and Master L2 ELL

Quick Demo

Place a beaker of lightly salted water on a table where it can be seen by students. Connect one end of a piece of wire to the positive terminal of a 9-volt battery. Connect a second piece of wire to the negative terminal of the battery. Place the other ends of the wires into the water; do not allow wires to touch. Instruct students to observe the ends of the wires for the appearance of bubbles. Explain that passing an electric current through water breaks the water apart, resulting in the elements oxygen and hydrogen.

GLENCOE TECHNOLOGY

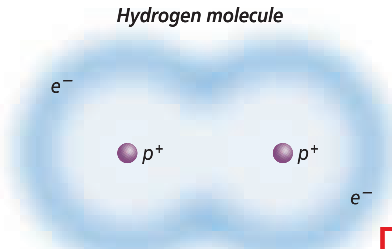
CD-ROM
Biology: The Dynamics of Life
Animation: *The Covalent Bond*
Animation: *The Ionic Bond*
Disc 1

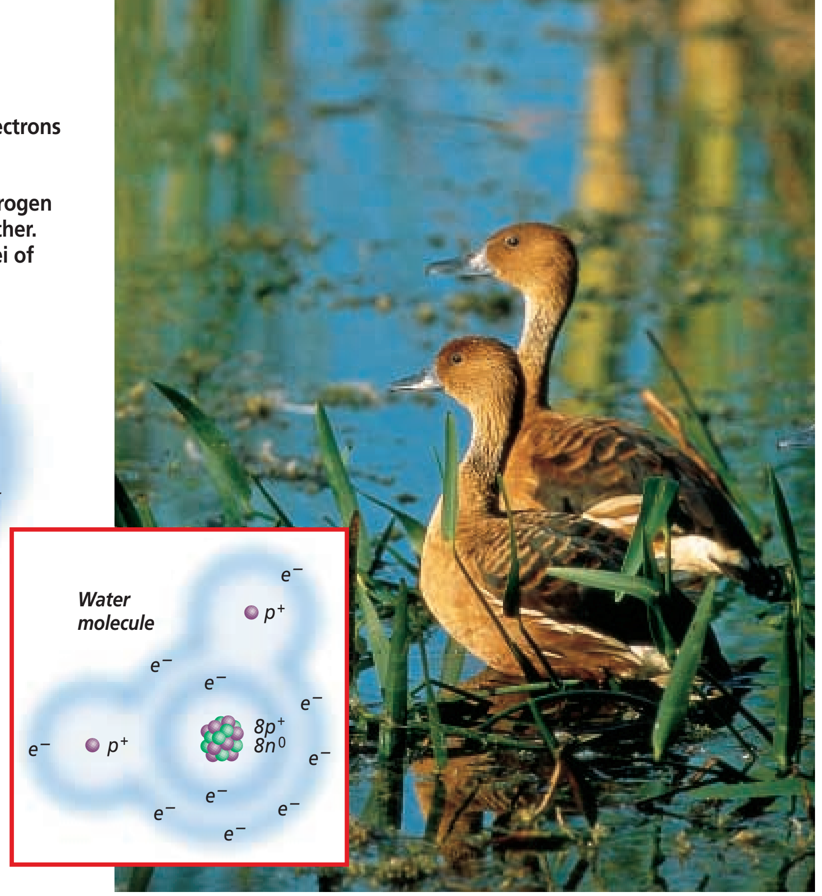
VIDEODISC
Biology: The Dynamics of Life
Covalent Bonding (Ch. 17)
Disc 1, Side 1
37 sec.
Ionic Bonding (Ch. 18)
Disc 1, Side 1
45 sec.

The Secret of Life
Water Molecule

Figure 6.6
Sometimes atoms combine by sharing electrons to form covalent bonds.

A Hydrogen gas (H_2) exists as two hydrogen atoms sharing electrons with each other. The electrons move around the nuclei of both atoms.





B When two hydrogens share electrons with oxygen, they form covalent bonds to produce a molecule of water.

CD-ROM
View an animation of covalent bonding in the Presentation Builder of the Interactive CD-ROM.

Remember electron energy levels? For most elements, an atom becomes stable when its outermost energy level is full, such as having eight electrons in the second level. An exception is hydrogen, which becomes stable when its first energy level is full (two electrons). How do elements fill the energy levels and become stable? One way is to share electrons with other atoms.

For example, two hydrogen atoms can combine with each other by sharing their electrons, as shown in *Figure 6.6*. As you know, individual atoms of hydrogen contain only one electron. Each atom becomes stable by sharing its electron with the other atom. The two shared electrons move about the first energy level of both atoms. The attraction of the positively charged nuclei for the shared, negatively charged electrons holds the atoms together. When two atoms share electrons, such as hydrogen sharing with oxygen in water, the force that holds them together is called a **covalent bond** (koh VAY lunt). Most compounds in organisms have covalent bonds. Examples include sugars, fats, proteins, and water.

A **molecule** is a group of atoms held together by covalent bonds and having no overall charge. A molecule of water is represented by the chemical formula H_2O. The subscript 2 represents two atoms of hydrogen (H) combined with one atom of oxygen (O). As you will see, many compounds in living things have more complex formulas.

How ionic bonds form

Not all atoms bond with each other by sharing electrons. Sometimes atoms combine with each other by gaining or losing electrons in their outer energy levels. An atom (or group of atoms) that gains or loses electrons has an electrical charge and is called an ion. An **ion** is a charged particle.

A different type of chemical bond holds ions together. The bond formed between a sodium atom (Na) and chlorine atom (Cl) is a good example of this. A sodium atom contains 11 electrons, including one in the third energy level. A chlorine atom has 17 electrons, with the outer level holding seven electrons. When sodium and chlorine combine, the sodium atom loses one electron, and the chlorine atom gains it. Thus, with eight electrons in its outer level, the chlorine ion formed is stable and has a negative charge. Sodium has lost the one electron that was in its third energy level. Thus, the sodium ion is stable and has a positive charge. The attractive force between two ions of opposite charge is known as an **ionic bond.** The bond between sodium and chlorine is an ionic bond, as shown in *Figure 6.7.*

Ionic compounds are less abundant in living things than are covalent molecules, but ions are important in biological processes. For example, sodium and potassium ions are required for transmission of nerve impulses. Calcium ions are necessary for muscles to contract. Plant roots absorb essential minerals in the form of ions.

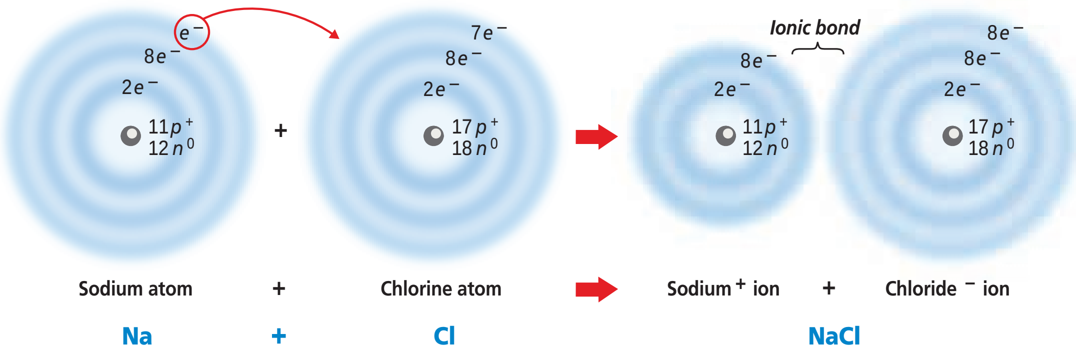
Chemical Reactions

When chemical reactions occur, bonds between atoms are formed or broken, causing substances to combine and recombine as different molecules. In organisms, chemical reactions occur over and over inside cells. All of the chemical reactions that occur within an organism are referred to as that organism's **metabolism.** These reactions break down and build molecules that are important

WORD Origin
metabolism
From the Greek word *metabole*, meaning "change." Metabolism involves many chemical changes.

CD-ROM
View an animation of ionic bonding in the Presentation Builder of the Interactive CD-ROM.

Figure 6.7
The positive charge of a sodium ion attracts the negative charge of a chlorine ion, and the elements combine with an ionic bond that forms explosively, as shown in the photograph.



Reinforcement

Logical-Mathematical Give students several chemical formulas related to living things, such as CO_2 and $C_6H_{12}O_6$. Have them practice identifying the elements in the compounds and the numbers of atoms of each type of element shown in each formula. L2

Chalkboard Example

Logical-Mathematical Write a few chemical equations on the chalkboard and work with students to balance the equations. Once the equations are balanced, have students confirm the balance by counting the number of atoms of each kind on each side of the equation. Reinforce the idea that atoms are never created or destroyed in ordinary reactions. Some possible equations are as follows. L1

$Mg + 2HCl \Rightarrow MgCl_2 + H_2$
$2C_2H_2 + 5O_2 \Rightarrow 2H_2O + 4CO_2$
$2H_2S + 3O_2 \Rightarrow 2H_2O + 2SO_2$

Resource Manager

Basic Concepts Transparency 5b and Master L2 ELL

Cultural Diversity

Kenichi Fukui and Chemical Reactions

In the 1950s, Japanese chemist Kenichi Fukui (1918–1998) developed the idea that chemical reactions occur as a result of interactions of the outer-level electrons of one atom or molecule with the outer-level electrons of another atom or molecule. In 1981, Fukui received the Nobel Prize for Chemistry for his investigations of the mechanisms of chemical reactions. Discuss with students the work of Kenichi Fukui toward understanding chemical interactions.

PROJECT

Modeling

Kinesthetic Have students build models of water molecules. Students may use toothpicks and gumdrops or colored marshmallows to represent the atoms in the molecule. L1 ELL

Enrichment

Prepare mixtures of sand and water (suspension) and salt and water (solution). Explain that the contents of both containers represent mixtures. Stir each container and ask students to describe any changes they observe in the appearance of the mixtures.

Use the observable traits of the mixtures to explain that there are different types of mixtures. Explain that the sand and water represent a suspension—a heterogeneous mixture consisting of finely divided particles of a solid temporarily suspended in a liquid. The salt and water are a solution—a mixture in which one or more substances are evenly distributed in another substance. L2 ELL

GLENCOE TECHNOLOGY

VIDEODISC
The Infinite Voyage
The Future of the Past
Preserving Frescoes in Florence
(Ch. 1) 9 min. 30 sec.

for the functioning of organisms. Scientists represent chemical reactions by writing chemical equations. Chemical equations use symbols and formulas to represent each element or substance.

Writing chemical equations

The events that take place when hydrogen gas combines with oxygen gas are shown in ***Figure 6.8***. Substances that undergo chemical reactions, such as hydrogen and oxygen, are called reactants. Substances formed by chemical reactions, such as water, are called products.

It's easy to tell how many molecules are involved in a reaction because the number before each chemical formula indicates the number of molecules of each substance. The subscript numbers in a formula indicate the number of atoms of each element in a molecule of the substance. A molecule of table sugar can be represented by the formula $C_{12}H_{22}O_{11}$. The lack of a number before a formula or under a symbol indicates that only one atom or molecule is present.

Looking at the equation in ***Figure 6.8***, you can see that each molecule of hydrogen gas is composed of two atoms of hydrogen. Likewise, a molecule of oxygen gas is made of two atoms. Perhaps the easiest way to understand chemical equations is to know that atoms are neither created nor destroyed in chemical reactions. They are simply rearranged. Therefore, an equation is written so that the same numbers of atoms of each element appear on both sides of the arrow. In other words, equations must always be written so that they are balanced.

Mixtures and Solutions

When elements combine to form a compound, the elements no longer have their original properties. What happens if substances are just mixed together and do not combine chemically? A **mixture** is a combination of substances in which the individual components retain their own properties. ***Figure 6.9*** shows a mixture of sand and sugar. If you stirred sand and sugar together, you could still tell the sand from the sugar. Neither component of the mixture would change, nor would they combine chemically. You could easily separate them by adding water to dissolve the sugar and then filtering the mixture to collect the sand.

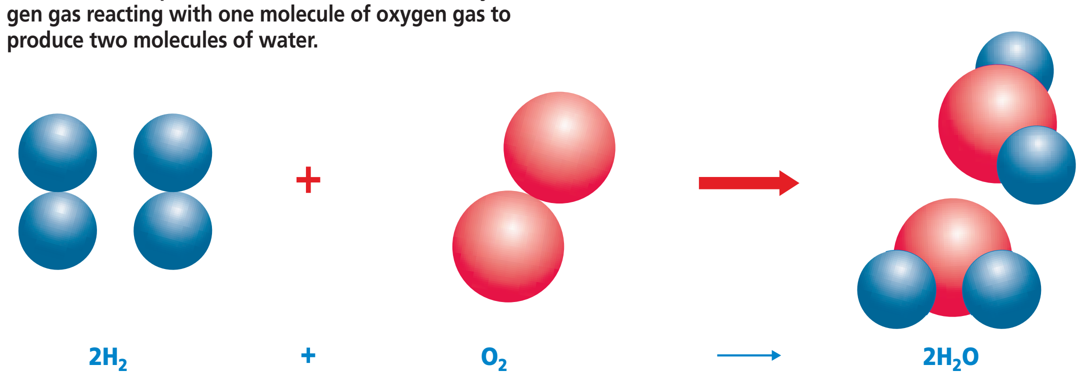


Figure 6.8
This balanced equation shows two molecules of hydrogen gas reacting with one molecule of oxygen gas to produce two molecules of water.

A **solution** is a mixture in which one or more substances (solutes) are distributed evenly in another substance (solvent). In other words, one substance is dissolved in another and will not settle out of solution. You may remember making Kool-Aid when you were younger. The sugar molecules in Kool-Aid dissolve easily in water to form a solution, as shown in ***Figure 6.10.***

Solutions are important in living things. In organisms, many vital substances, such as sugars and mineral ions, are dissolved in water. The more solute that is dissolved in a given amount of solvent, the greater is the solution's concentration (strength). The concentration of a solute is important to organisms. Organisms can't live unless the concentration of dissolved substances stays within a specific, narrow range. Organisms have many mechanisms to keep the concentrations of molecules and ions within this range. For example, the pancreas and other organs in your body produce substances that keep the amount of sugar dissolved in your bloodstream within a critical range.

Figure 6.9
This combination of sand and sugar illustrates a mixture. Both components retain their original properties.

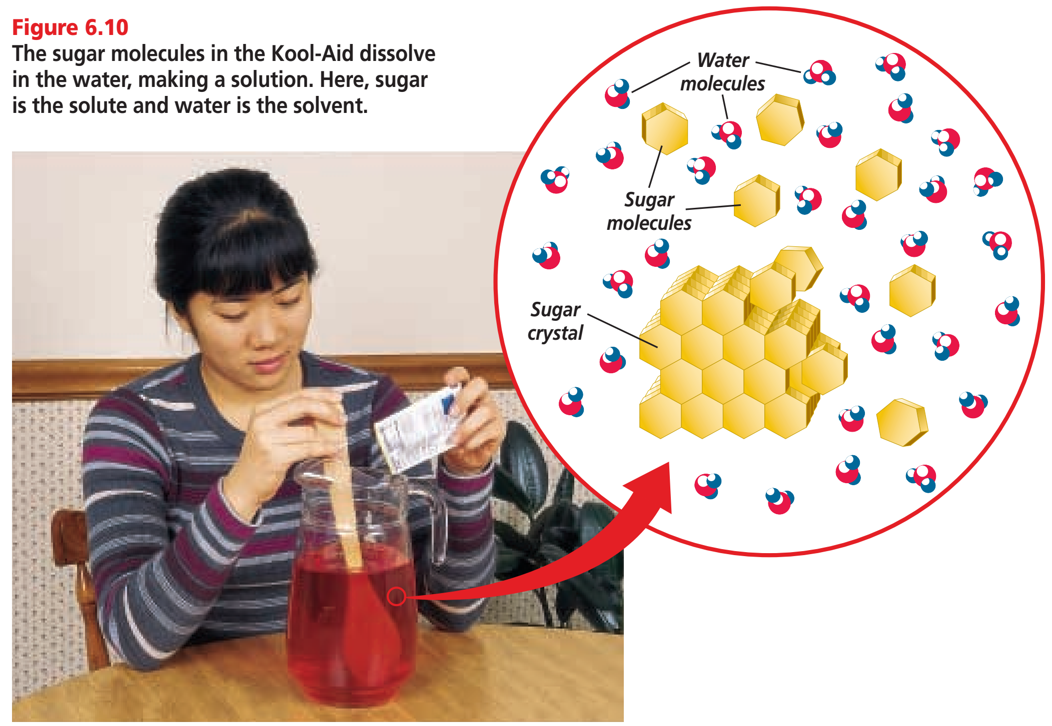


Figure 6.10
The sugar molecules in the Kool-Aid dissolve in the water, making a solution. Here, sugar is the solute and water is the solvent.

Using Science Terms

Tell students to imagine they are making a glass of lemonade from a mix. Ask: "Which part of the resulting solution is the solute? Which is the solvent?" *The lemonade mix is the solute because it is the material being dissolved. The water in which the mix is dissolved is the solvent.* L1

3 Assess

Check for Understanding

Visual-Spatial Refer students to the periodic table. Provide students with a list of several common elements. For each element, ask students to give the correct symbol and diagram the atom's structure to show its protons, neutrons, and electron energy levels. L2

Reteach

Kinesthetic Using gumdrop and toothpick molecules, demonstrate a chemical reaction such as $CH_4 + 2O_2 \Rightarrow CO_2 + 2H_2O$. Stress the conservation of matter as students tear the original molecules apart to build new molecules. L1 ELL

Extension

Visual-Spatial Ask students to make a display to show the chemical formulas of ten common substances. L3

Assessment

Skill Give students the following equations to balance. L2

$N_2O_4 \Rightarrow NO_2$

$C_3H_8 + O_2 \Rightarrow CO_2 + H_2O$

BIOLOGY JOURNAL

Concept Mapping

Have students create a concept map showing the relationships among elements, mixtures, compounds, and solutions. The following terms should be included: atoms, elements, molecules, compounds, mixtures, solutions, solvent. Students may add other terms and should supply their own connecting words. L2

Portfolio

Mixtures and Compounds

Intrapersonal Have students construct a table to compare and contrast mixtures and compounds. Encourage students to reread the section entitled "Mixtures and Compounds" to find the information needed to complete their tables. L2 P

Resource Manager

Reinforcement and Study Guide
pp. 25-26 L2

Careers in Biology

Education

Courses in high school: chemistry, mathematics, biology, and carpentry
College: a degree in biology for managers or supervisors
Other education sources: on-the-job training and correspondence courses

Career Issue

Ask students whether weed and pest control technicians should tell their customers about non-chemical ways to control weeds and insects? Why or why not?

For More Information

For more information about pest control, write to:

National Pest Control Association
8100 Oak Street
Dunn Loring, VA 22027

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Exploration: *Acid Base Test*
Disc 1

4 Close

Activity

Kinesthetic Have students build a model of an element, such as oxygen, using navy beans for electrons, pinto beans for neutrons, and kidney beans for protons. L1 ELL

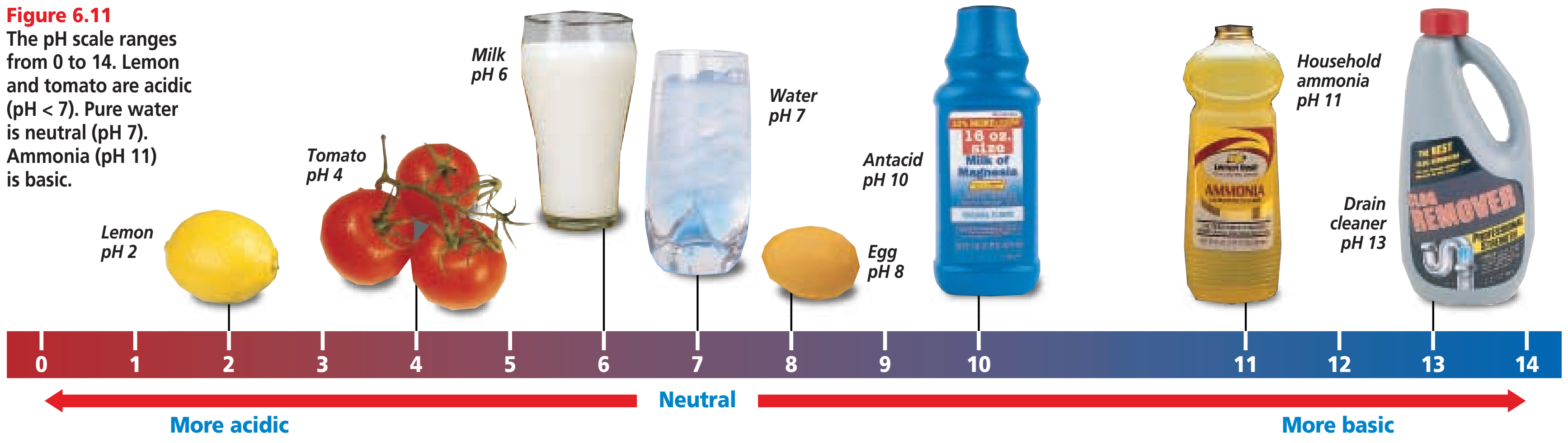


Figure 6.11 The pH scale ranges from 0 to 14. Lemon and tomato are acidic (pH < 7). Pure water is neutral (pH 7). Ammonia (pH 11) is basic.

Careers in Biology

Weed/Pest Control Technician

A career working with chemicals does not always require a Ph.D. Weed and pest control technicians use chemicals to get rid of unwanted weeds, insects, and other pests.

Skills for the Job

After high school, most technicians receive on-the-job training in pest control or take correspondence courses to earn a degree in this field. In many states, you must pass a test to become licensed.

As a technician, you may visit homes, office buildings, restaurants, hotels, and other places where insects, animals, or weeds have become a problem. You will choose the correct chemical and form, such as a spray or gas, to get rid of or prevent infestations of flies, roaches, termites, or other creatures. You will select different chemicals to deal with weeds. You might also set traps to catch rats, mice, moles, or other animals.

interNET CONNECTION To find out more about careers in related fields, visit the Glencoe Science Web Site.
www.glencoe.com/sec/science

Acids and bases

Chemical reactions can occur only when conditions are right. For example, a reaction might depend on temperature, the availability of energy, or a certain concentration of a substance dissolved in solution. Chemical reactions in organisms also depend on the pH of the environment. The **pH** is a measure of how acidic or basic a solution is. A scale with values ranging from 0 to 14 is used to measure pH. Indicators like pH paper describe the pH of substances like those shown in ***Figure 6.11.***

Substances with a pH below 7 are acidic. An **acid** is any substance that forms hydrogen ions (H^+) in water. When the compound hydrogen chloride (HCl) is added to water, hydrogen ions (H^+) and chloride ions (Cl^-) are formed. Thus, hydrogen chloride in solution is called hydrochloric acid. This acidic solution contains an abundance of H^+ ions and has a pH below 7.

Substances with a pH above 7 are basic. A **base** is any substance that forms hydroxide ions (OH^-) in water. For example, if sodium hydroxide (NaOH) is dissolved in water, it forms sodium ions (Na^+) and hydroxide ions (OH^-). This basic solution contains an abundance of OH^- ions and has a pH above 7.

Acids and bases are important to living systems, but strong acids and bases can also be dangerous. For example, some plants grow well only in acidic soil, whereas others require soil that is basic. Another example, orange juice, is a common acid that can corrode immature teeth if the acid is not later rinsed away. The *MiniLab* shown here describes how you can investigate several household solutions to determine if they are acids or bases.

MiniLab 6-1 Experimenting

Determine pH The pH of a solution is a measurement of how acidic or basic that solution is. An easy way to measure the pH of a solution is to use pH paper.

Household Solutions

Procedure

1. Pour a small amount (about 5 mL) of each of the following into separate clean, small beakers or other small glass containers: lemon juice, household ammonia solution, liquid detergent, shampoo, and vinegar.
2. Dip a fresh strip of pH paper briefly into each solution and remove.
3. Compare the color of the wet paper with the pH color chart; record the pH of each material. **CAUTION:** ***Wash your hands after handling lab materials.***

Analysis

1. Which solutions are acids?
2. Which solutions are bases?
3. What ions in the solution caused the pH paper to change? Which solution contained the highest concentration of hydroxide ions? How do you know?

Section Assessment

Understanding Main Ideas

1. Describe where the electrons are located in an atom.
2. A nitrogen atom contains seven protons, seven neutrons, and seven electrons. Describe the structure of a nitrogen atom. Use a labeled drawing to help you explain this structure.
3. How does the formation of an ionic bond differ from the formation of a covalent bond?
4. What can you say about the proportion of hydrogen ions and hydroxide ions in a solution that has a pH of 2?

Thinking Critically

5. A fluorine atom has nine electrons. Make an energy level diagram of fluorine. How many electrons would be needed to fill its outer level?

Skill Review

6. **Interpreting Scientific Illustrations** Study the diagram in ***Figure 6.10,*** which shows the process of a polar compound dissolving in water. Describe the process step-by-step. Tell what the water molecules are doing and why. Describe what is happening to the sugar molecules and why. Describe the nature of the mixture after the compound dissolves. For more help, refer to *Thinking Critically* in the **Skill Handbook.**

MiniLab 6-1

Purpose

Students will determine the pH of common solutions.

Process Skills

observe and infer, interpret data

Safety Precautions

Have students wear aprons and safety goggles. **CAUTION:** ***Both high and low pH solutions can injure the skin and eyes.*** Have students wash hands after this activity.

Teaching Strategies

- Use a pH paper that measures from pH 0 to 14.

Expected Results

The approximate pH of the solutions are: lemon juice, pH 3; household ammonia, pH 11; liquid detergent, pH 10; shampoo, pH 7; and vinegar, pH 3.

Analysis

1. lemon juice and vinegar
2. household ammonia and liquid detergent
3. H^+ ions and OH^- ions. Household ammonia contains the most OH^- ions; it had the highest pH.

Assessment

Portfolio Have students make a pH scale in their portfolios and show where each solution falls on the scale. Use the Performance Task Assessment List for Scientific Drawing in **PASC**, p. 55. L1 ELL

Meeting Individual Needs

Gifted

Logical-Mathematical Provide students with several chemical formulas, including some with coefficients. Have them determine how many atoms of each element are represented in each formula. Students can also draw diagrams giving the molecular structure of the compounds. L3 ELL

Resource Manager

Content Mastery, p. 30 L1
BioLab and MiniLab Worksheets p. 27 L2

Section Assessment

1. Electrons move around the nucleus in regions known as energy levels.
2. The nucleus contains seven protons and seven neutrons. The first energy level contains two electrons. The next energy level contains five electrons.
3. Ionic bonds form as one atom gains electrons from another or gives up electrons to another. Covalent bonds involve sharing of electrons.
4. There are more hydrogen than hydroxide ions in an acidic solution of pH 2.
5. The diagram should show two energy levels containing two and seven electrons, respectively. One electron is needed to fill the outer level.
6. Polar water molecules attract and surround the polar sugar molecules. Eventually, this attraction pulls the molecules of the sugar crystal apart. A solution of a molecular substance consists of water molecules and solute molecules.

Section 6.2

Prepare

Key Concepts

Students will develop an understanding of the properties of water that make it an excellent solvent and a necessary biological component. Students will also study the process of diffusion.

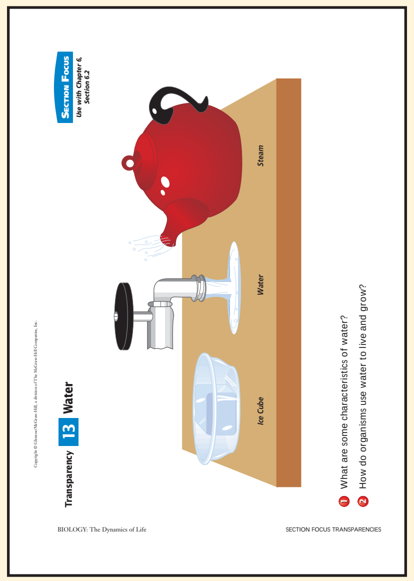
Planning

- Buy a roll of paper towels for the Quick Demo.
- Obtain marbles and plastic container for Reteach.
- Buy potatoes for MiniLab 6-2.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 13** on the overhead projector and have students answer the accompanying questions. L1 ELL



SECTION PREVIEW

Objectives

Relate water's unique features to polarity.

Explain how the process of diffusion occurs and why it is important to cells.

Vocabulary

polar molecule
hydrogen bond
diffusion
dynamic equilibrium

Section 6.2 Water and Diffusion

Most of us take water for granted. We turn on the kitchen faucet at home to get a drink and expect water to come out of the faucet. When we hike in a forest, we expect water to be flowing in the streams and filling the lakes. Most of the time, we don't think about how important water is to our life and the life of other organisms on Earth.

Water is vital to the living world.

Water and Its Importance

Water is perhaps the most important compound in living organisms. Most life processes can occur only when molecules and ions are free to move and collide with one another. This condition exists when they are dissolved in water. Water also serves as a means of material transportation in organisms. For example, blood and plant sap, which are mostly water, transport materials in animals and plants. In fact, water makes up 70 to 95 percent of most organisms.

Water is polar

Sometimes, when atoms form covalent bonds, they do not share the electrons equally. The water molecule pictured in *Figure 6.12* shows that the shared electrons are attracted by the oxygen atom more strongly than by the hydrogen atoms. As a result, the electrons spend more time near the oxygen atom than they do near the hydrogen atoms.

When atoms in a covalent bond do not share the electrons equally, they form a polar molecule. A **polar molecule** is a molecule with an unequal distribution of charge; that is, each molecule has a positive end and a negative end. Water is an example of a polar molecule. Polar water molecules attract each other as well as ions and other polar molecules. Because of this attraction, water can dissolve many ionic compounds, such as salt, and many other polar molecules, such as sugar.

Water molecules also attract other water molecules. The positively charged hydrogen atoms of one water molecule attract the negatively charged oxygen atoms of another water molecule. This attraction of opposite charges between hydrogen and oxygen forms a weak bond called a **hydrogen bond.** Hydrogen bonds are important to organisms because they help hold many large molecules, such as proteins, together.

Also because of its polarity, water has the unique property of being able to creep up thin tubes. Plants in particular take advantage of this property, called capillary action, to get water from the ground. Capillary action and the tension on the water's surface, which is also a result of polarity, play major roles in getting water from the soil to the tops of even the tallest trees.

Water resists temperature changes

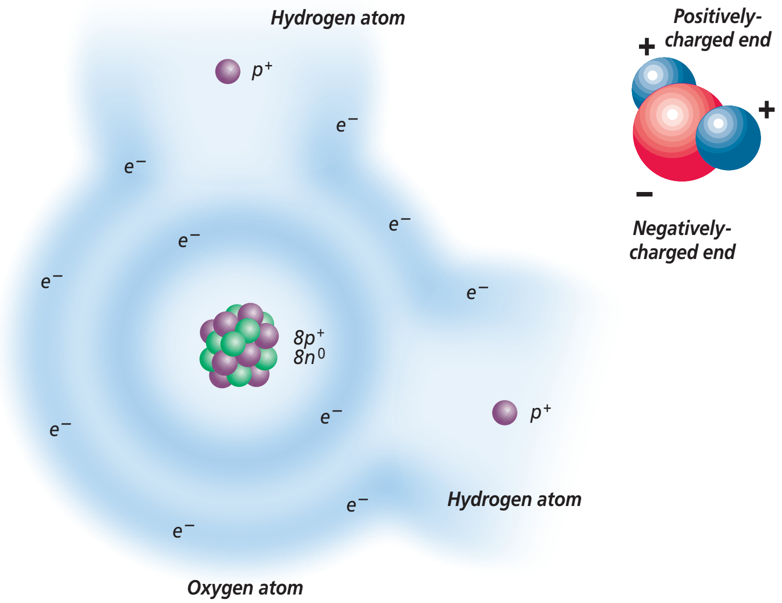
Water resists changes in temperature. Therefore, water requires more heat to increase its temperature than do most other common substances. Likewise, water loses a lot of heat when it cools. In fact, water is like an insulator that helps maintain a steady environment when conditions may fluctuate. Because cells exist in an aqueous environment, this property of water is extremely important to cellular functions as it helps cells maintain an optimum environment.

Water expands when it freezes

Water is one of the few substances that expands when it freezes. Because of this property, ice is less dense than liquid water and floats as it forms in a pond. Use the *Problem-Solving Lab* on the next page to investigate this property. Water expands as it freezes inside the cracks of rocks. As it expands, it often breaks apart the rocks. Over long time periods, this process forms soil.

The properties of water make it an excellent vehicle for carrying substances in living systems. Another way to move substances is by diffusion.

Figure 6.12 Because of water's bent shape, the protruding oxygen end of the molecule has a slight negative charge, and the ends with protruding hydrogen atoms have a slight positive charge.



2 Teach

Quick Demo

Logical-Mathematical Ask students to explain the water movement as you dip the edge of a paper towel in a bowl of water. L2 ELL

Concept Development

The solubility of oxygen in water increases as water temperature decreases. Ask students to explain why having water at a temperature of 2°C under a sheet of ice would be important for living organisms in terms of oxygen solubility. *The water at 2°C will dissolve more oxygen than the warmer layers of water beneath this layer. As the surface of the lake is sealed by ice, the temperature of the water becomes important to the ability of the water to provide enough oxygen to the aquatic organisms during winter.*

GLENCOE TECHNOLOGY

VIDEODISC
Biology: The Dynamics of Life
Properties of Water (Ch. 19)
Disc 1, Side 1,
45 sec.

Resource Manager

Section Focus Transparency 13 and Master L1 ELL
Concept Mapping, p. 6 L3 ELL

Meeting Individual Needs

Gifted

Intrapersonal Some bacteria can live on the underside of snow. Ask gifted students to research how these bacteria keep from freezing. L3

Biology Journal

"Water, water everywhere..."

Visual-Spatial Have students cut out pictures from magazines that illustrate uses of water. Ask them to prepare a display of their pictures. Students may want to include industrial uses of water, uses of water by organisms, or environmental uses of water. L1 ELL

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Video: *Properties of Water*
Disc 1

Problem-Solving Lab 6-2

Purpose Students will calculate the densities for water and ice and will correlate this information with the fact that water expands as it freezes.

Process Skills

compare and contrast, draw a conclusion, measure in SI, think critically, use numbers, recognize cause and effect

Teaching Strategies

- Review the equation for calculating density. Provide some examples for students to use as practice.
- Review the use of units such as cm^3 and mL if necessary.
- Remind students that cm^3 is the same as cubic centimeters or cc.
- Review the procedure for arriving at the proper units to express density.

Thinking Critically

1. The density of water is 1 g/cm^3; density of ice is 0.9 g/cm^3. Ice is less compact; mass in example is the same, but volume for ice is greater. A lower density indicates a greater volume with the same mass as water.
2. farther apart. This pattern accounts for increased volume.
3. Water expands as it freezes and eventually breaks glass.
4. Formation of ice crystals and the expansion within delicate cells and tissues could damage a living organism.

Assessment

Knowledge Have students describe the type of laboratory equipment they would need to measure the density of sea water. Use the Performance Task Assessment List for Designing an Experiment in **PASC**, p. 23. L2

Problem-Solving Lab 6-2 — Using Numbers

Why does ice float? Most liquids contract when frozen. Water is different; it expands. Freezing changes the density of water to that of ice, which allows ice to float. Density refers to compactness and is often described as the mass of a substance per unit of volume. A mathematical expression of density would read as follows:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Analysis

Examine the following table. It shows the volume and mass for a sample of water and ice.

Data Table

Source of sample	Volume (cm^3)	Mass (g)
Water	126	126
Ice	140	126

Thinking Critically

1. How does the density of ice compare with the density of water? Use specific values and proper units expressing density in your answer. Which of the two, ice or water, is less compact? Explain your answer.
2. Are the molecules of water moving closer together toward one another or farther apart as water freezes? Explain your answer.
3. Explain why a glass bottle filled with water will shatter if placed in a freezer.
4. Explain why ice forming within a living organism may result in its death.

Diffusion

All objects in motion have energy of motion called kinetic energy. A moving particle of matter moves in a straight line until it collides with another particle, much like the Ping-Pong balls shown in *Figure 6.13*. After the collision, both particles rebound. Particles of matter, like the Ping-Pong balls, are in constant motion, colliding with each other.

Early observations: Brownian motion

In 1827, Scottish scientist Robert Brown used a microscope to observe pollen grains suspended in water. He noticed that the grains moved constantly in little jerks, as if being struck by invisible objects. This motion, he thought, was the result of a life force hidden within the pollen grains. However, when he repeated his experiment using dye particles, which are nonliving, he saw the same erratic motion. This motion is now called Brownian motion. Brown had no explanation for the motion he saw, but today we know that Brown was observing evidence of the random motion of molecules. This was the invisible "life" that was moving the tiny visible particles. The random movement that Brown observed is characteristic of gas, liquid, and some solid molecules.

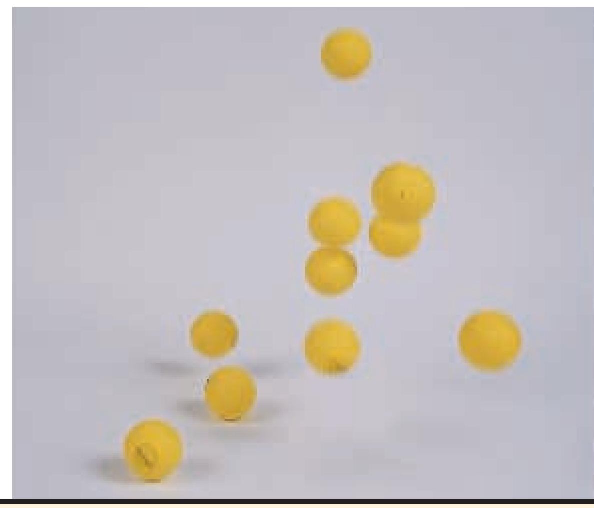


Figure 6.13 Molecules, like these Ping-Pong balls, have kinetic energy, the energy of motion.

The process of diffusion

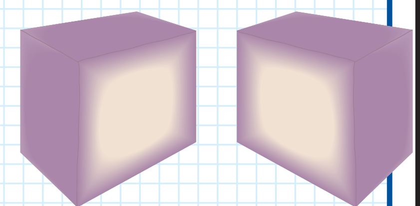
Molecules of different substances that are in constant motion have an effect on each other. For example, if you layer pure corn syrup on top of corn syrup colored with food coloring in a beaker as illustrated in *Figure 6.14*, over time you will observe the colored corn syrup mixing with the pure corn syrup. This mixture is the result of the random movement of corn syrup molecules. **Diffusion** is the net movement of particles from an area of higher concentration to an area of lower concentration. Diffusion results because of the random movement of particles (Brownian motion). The corn syrup in *Figure 6.14* will begin to diffuse in hours but will take months to mix completely.

Diffusion is a slow process because it relies on the random molecular motion of atoms. Three key factors, concentration, temperature, and pressure, affect the rate of diffusion. The concentration of the substances involved is the primary controlling factor. The more concentrated the substances, the more rapidly diffusion occurs. For example, loose sugar placed in water will diffuse more rapidly than will a more concentrated cube of sugar. Two external factors, temperature and pressure, can speed the process of diffusion. An increase in temperature or agitation will cause more rapid molecular movement and will speed diffusion. Similarly, increasing pressure will accelerate molecular movement and, therefore, diffusion. With common materials, you can use the *MiniLab* shown here to learn more about diffusion in a cell.

Figure 6.14 The random movement of particles of corn syrup will cause the colored sample to diffuse into the uncolored sample.

MiniLab 6-2 — Applying Concepts

Examine the Rate of Diffusion In this lab, you will place a small potato cube in a solution of potassium permanganate and observe how far the dark purple color diffuses into the potato after a given length of time.



Procedure

1. Using a single-edge razor blade, cut a cube 1 cm on each side from a raw, peeled potato. **CAUTION:** ***Be careful with sharp objects.*** Do not cut objects while holding them in your hand.
2. Place the cube in a cup or beaker containing the purple solution. The solution should cover the cube. Note and record the time. Let the cube stand in the solution for between 10 and 30 minutes.
3. Using forceps, remove the cube from the solution and note the time. Cut the cube in half.
4. Measure, in millimeters, how far the purple solution has diffused, and divide this number by the time you allowed your potato to remain in the solution. This is the diffusion rate.

Analysis

1. How far did the purple solution diffuse?
2. What was the rate of diffusion per minute?

MiniLab 6-2

Purpose Students will determine the rate of diffusion of a solution.

Process Skills

measure in SI, collect and organize data, interpret data, experiment, and analyze

Teaching Strategies

- Regarding safety, caution students that the solution can be caustic. If they get some on their hands, they should wash immediately. To keep the solution off their hands, students should set the cube on waxed paper or foil when they remove it from the solution and hold the cube with the forceps as it is cut. Also remind students to cut away from their body.

Expected Results

The color will diffuse only a few millimeters into the cube, the exact distance depending upon the amount of time it is in the solution.

Analysis

1. Answers will depend on the amount of time the cube is in the solution.
2. The rate will be in tenths to hundredths of millimeters per minute.

Assessment

Portfolio Have students write a report of the MiniLab for their portfolios. Use the Performance Task Assessment List for Lab Report in **PASC**, p. 47. L2

Biology Journal

Kinetic Energy

Visual-Spatial In their journals, have students draw a diagram and describe another example of kinetic energy. You might discuss some popular children's toys or microwave popcorn to get them started. L2 ELL

GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
Diffusion of Water

Portfolio

The Importance of Water

Linguistic Have students write an essay that explains why water is important to them. Ask them to think about their families' daily use of water. Challenge them to think about what uses are especially important in view of the fact that they might someday have to cut their water use in half. L2 P

Resource Manager

Reinforcement and Study Guide, p. 27 L2
Content Mastery, pp. 30-31 L1
BioLab and MiniLab Worksheets, p. 28 L2

3 Assess

Check for Understanding

Quiz students orally about the importance of water to living organisms and test their understanding of each of the properties of water. L2

Reteach

Visual-Spatial In a clear container with a lid, place 10–15 marbles of one color. On top of those marbles, place an equal number of different colored marbles. Ask students to predict what will occur if you shake the container continuously. *Like diffusion, the marbles will eventually disperse among each other, reaching an equilibrium of mixed color.* L1 ELL

Extension

Intrapersonal Have students research how rapidly molecules can actually move over a particular distance. L3

Assessment

Knowledge Have students list the properties of water and give an example of how each property is useful in a living organism. L2

4 Close

Activity

Logical-Mathematical Place a watch glass containing mint oil on the front desk. Have students discuss how the molecules of mint are reaching them. *Besides diffusion, which is a slow process, air currents are also carrying the molecules to their noses.* L2

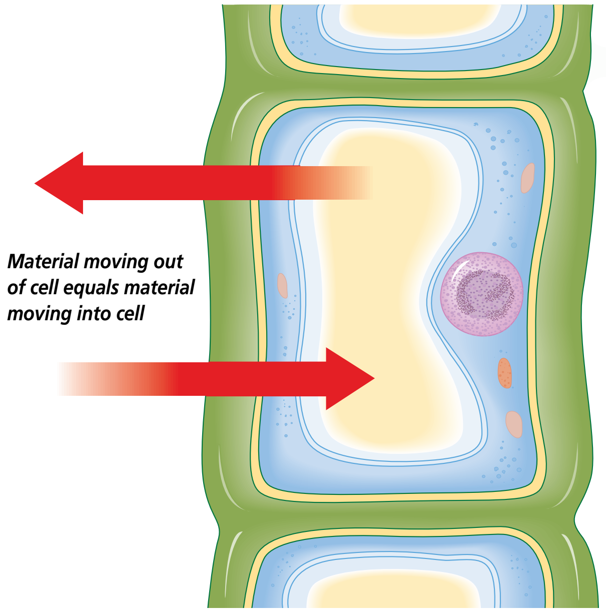


Figure 6.15
When a cell is in dynamic equilibrium with its environment, materials move into and out of the cell at equal rates. As a result, there is no net change in concentration inside the cell.

The results of diffusion

As the colored corn syrup continues to diffuse into the pure corn syrup, the two will become evenly distributed eventually. After this point, the atoms continue to move randomly and collide with one another; however, no further change in concentration will occur. This condition, in which there is continuous movement but no overall concentration change, is called **dynamic equilibrium.** *Figure 6.15* illustrates dynamic equilibrium in a cell.

Diffusion in living systems

Most substances in and around a cell are in water solutions where the ions and molecules of the solute are distributed evenly among water molecules, like the Kool-Aid and water example. The difference in concentration of a substance across space is called a concentration gradient. Because ions and molecules diffuse from an area of higher concentration to an area of lower concentration, they are said to move with the gradient. If no other processes interfere, diffusion will continue until there is no concentration gradient. At this point, dynamic equilibrium occurs. Diffusion is one of the methods by which cells move substances in and out of the cell.

Diffusion in biological systems is also evident outside of the cell and can involve substances other than molecules in an aqueous environment. For example, oxygen (a gas) diffuses into the capillaries of the lungs because there is a greater concentration of oxygen in the air sacs of the lungs than in the capillaries.

Section Assessment

Understanding Main Ideas

1. Explain why water is a polar molecule.
2. How does a hydrogen bond compare to a covalent bond?
3. What property of water explains why it can travel to the tops of trees?
4. What is the eventual result of diffusion? Describe concentration prior to and at this point.

Thinking Critically

5. Explain why water dissolves so many different substances.

Skill Review

6. **Inferring** If a substance is known to enter a cell by diffusion, what effect would raising the temperature have on the cell? For more help, refer to *Thinking Critically* in the **Skill Handbook.**

Section Assessment

1. The oxygen and two hydrogens do not share the electrons equally (electrons are more often near the oxygen). As a result, the oxygen is negatively charged and the hydrogens are positively charged.
2. Hydrogen bonds are very weak compared with covalent bonds.
3. capillary action
4. The particles will reach dynamic equilibrium.
5. Because water molecules are polar and attract other charged particles, water easily dissolves many substances.
6. An increase in temperature causes an increase in kinetic energy and the rate of diffusion of the substance into the cell.

Section
6.3 Life Substances

SECTION PREVIEW

Objectives

Classify the variety of organic compounds.

Describe how polymers are formed and broken down in organisms.

Compare the chemical structures of carbohydrates, lipids, proteins, and nucleic acids, and relate their importance to living things.

Vocabulary

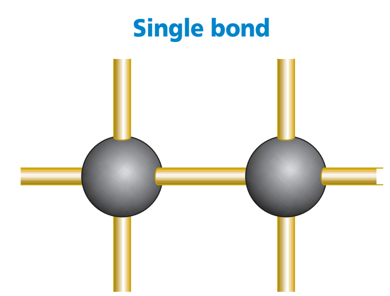
isomer
polymer
carbohydrate
lipid
protein
amino acid
peptide bond
enzyme
nucleic acid
nucleotide

Did you ever hear the saying, "You are what you eat"? It's at least partially true because the compounds that form the cells and tissues of your body are produced from similar compounds in the foods you eat. Common to most of these foods and to most substances in organisms is the element carbon. The first carbon compounds that scientists studied came from organisms and were called organic compounds.

Carbon defines living organisms.

Role of Carbon in Organisms

A carbon atom has four electrons available for bonding in its outer energy level. In order to become stable, a carbon atom forms four covalent bonds that fill its outer energy level. Look at the illustration showing carbon atoms and bond types in *Figure 6.16.* Carbon can bond with other carbon atoms, as well as with many other elements. When each atom shares two electrons, a double bond is formed. A double bond is represented by two bars between carbon atoms. When each shares three electrons, a triple bond is formed. Triple bonds are represented by three bars drawn between carbon atoms.



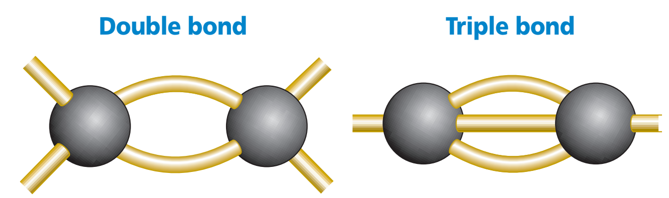


Figure 6.16
When two carbon atoms bond, they share one, two, or three electrons each and form a covalent bond.

Meeting Individual Needs

Hearing Impaired

Interpersonal Make visual cards with pictures of foods that are associated with carbohydrates, lipids, and proteins. On each card ask what organic compound is predominant or what monomers are involved. Have students work in groups to answer the questions. L2 COOP LEARN

Biology Journal

Summarizing Carbon

Linguistic Have students write a paragraph or two summarizing the properties of carbon and describing why carbon is so important to living things. L2

Section 6.3

Prepare

Key Concepts

Students will examine the classes of carbon compounds present in organisms. The structural and functional aspects of carbohydrates, lipids, proteins, and nucleic acids will be studied.

Planning

- Collect potatoes, knives, hydrogen peroxide and waxed paper for the BioLab.
- Purchase grocery and paper items for the Alternative Lab.
- Make flash cards for the Check for Understanding.

1 Focus

Bellringer

Before presenting the lesson, display **Section Focus Transparency 14** on the overhead projector and have students answer the accompanying questions. L1 ELL

2 Teach

Visual Learning

Figure 6.17 Direct students' attention to the illustration. Ask them what compound in addition to sucrose is formed when glucose and fructose combine. *water*

Assessment

Knowledge Have volunteers draw a model of a carbon atom on the chalkboard. Have one student draw the protons, a second student draw the neutrons, and a third student add the electrons in their correct energy levels. Ask students to use the model to explain how many electrons are needed to make the carbon atom stable. *four* Have students predict how many hydrogen atoms could form covalent bonds with the carbon atom. *four* Ask what the formula for this molecule would be. CH_4 L2 ELL

GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
Carbon Bonds

Resource Manager

Section Focus Transparency 14 and Master L1 ELL
Critical Thinking/Problem Solving, p. 6 L3

Word Origin

polymer
From the Greek words *poly*, meaning "many," and *meros*, meaning "part." A polymer has many bonded subunits (parts).

hydrolysis
From the Greek words *hydro*, meaning "water," and *lysis*, meaning "to split or loosen." In hydrolysis, molecules are split by water.

When carbon atoms bond to each other, they can form straight chains, branched chains, or rings. In addition, these chains and rings can have almost any number of carbon atoms and can include atoms of other elements as well. This property makes a huge number of carbon structures possible. In addition, compounds with the same simple formula often differ in structure. Compounds that have the same simple formula but different three-dimensional structures are called **isomers** (I suh murz). The glucose and fructose molecules shown in *Figure 6.17* have the same simple formula, $C_6H_{12}O_6$, but different structures.

Molecular chains

Carbon compounds also vary greatly in size. Some compounds contain just one or two carbon atoms, whereas others contain tens, hundreds, or even thousands of carbon atoms. These large molecules are called macromolecules. Proteins are examples of macromolecules in organisms. Cells build macromolecules by bonding small molecules together to form chains called polymers. A **polymer** is a large molecule formed when many smaller molecules bond together.

Condensation is the chemical reaction by which polymers are formed. In condensation, the small molecules that are bonded together to make a polymer have an –H and an –OH group that can be removed to form H–O–H, a water molecule. The subunits become bonded by a covalent bond as shown in *Figure 6.18*.

Hydrolysis is a method by which polymers can be broken apart. Hydrogen ions and hydroxide ions from water attach to the bonds between the subunits that make up the polymer, thus breaking the polymer as shown in *Figure 6.18*.

The structure of carbohydrates

You may have heard of runners eating large quantities of spaghetti or other starchy foods the day before a race. This practice is called "carbohydrate loading." It works because carbohydrates are used by cells to store and release energy. A **carbohydrate** is an organic compound composed of carbon, hydrogen, and oxygen with a ratio of about two hydrogen atoms and one oxygen atom for every carbon atom.

The simplest type of carbohydrate is a simple sugar called a monosaccharide (mahn uh SAK uh ride). Common examples are the isomers glucose and fructose. Two monosaccharide molecules can link together to form a disaccharide, a two-sugar carbohydrate. When glucose and fructose combine by a condensation reaction, a molecule of sucrose, known as table sugar, is formed.

The largest carbohydrate molecules are polysaccharides, polymers composed of many monosaccharide subunits. The starch, glycogen, and cellulose pictured in *Figure 6.19* are examples of polysaccharides. Starch consists of highly branched chains of glucose units and is used as food storage by plants in food reservoirs such as seeds and bulbs. Mammals store food in the liver in the form of glycogen, a glucose polymer similar to

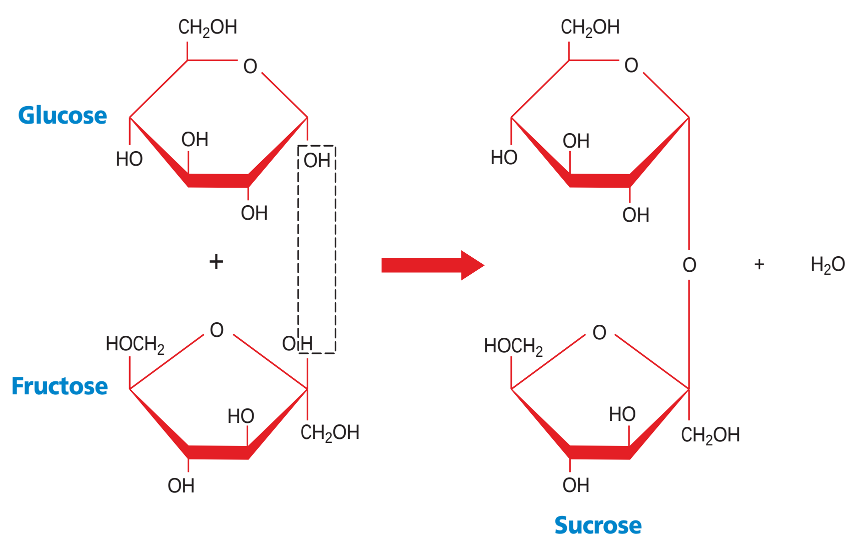
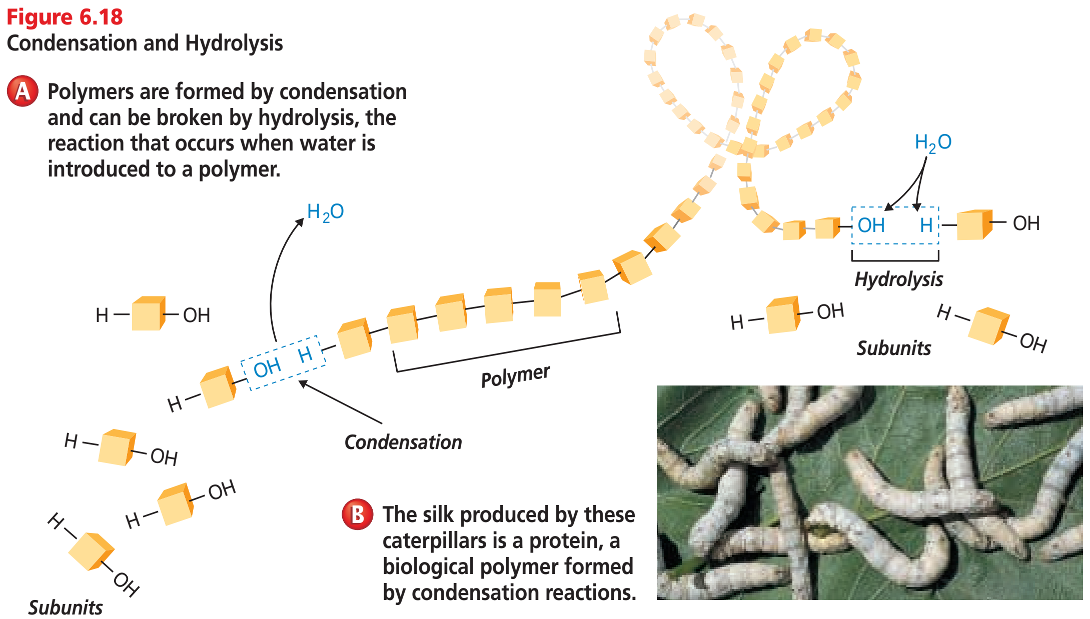


Figure 6.17
The different arrangement of hydrogen and oxygen atoms around each carbon atom gives glucose and fructose molecules different chemical properties. When glucose and fructose combine, they form the disaccharide sucrose, also known as table sugar.

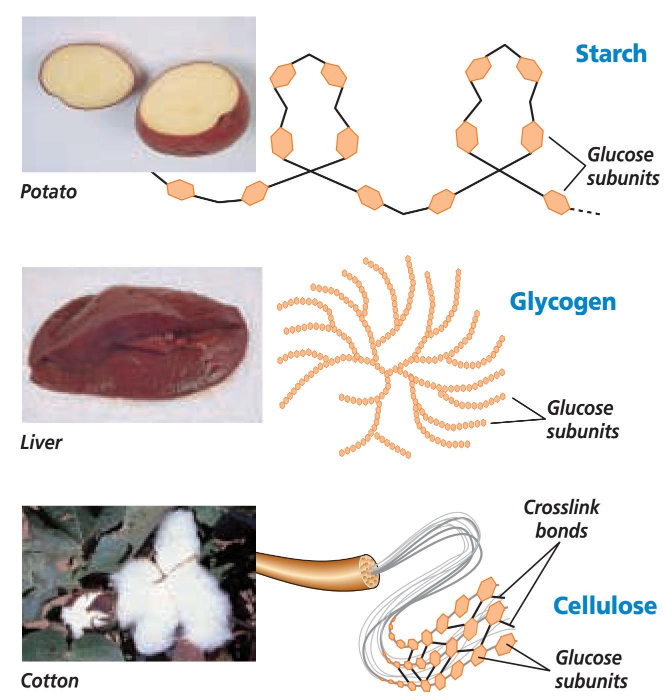
Figure 6.18
Condensation and Hydrolysis

A Polymers are formed by condensation and can be broken by hydrolysis, the reaction that occurs when water is introduced to a polymer.



B The silk produced by these caterpillars is a protein, a biological polymer formed by condensation reactions.

Figure 6.19
Look at the structural differences among the polysaccharides starch, glycogen, and cellulose. Notice that all three are polymers of glucose.



Quick Demo

Use a ball-and-stick model of a methane molecule (CH_4) to show students the regular tetrahedron arrangement formed by the bonds of carbon atoms. Contrast the arrangement of the atoms in the methane molecule to those in a molecule of water.

Using Science Terms

Linguistic Have students look up the meanings of the prefix "hydro" and the suffix "lysis" in a dictionary. *Hydro- refers to water, and lysis means to break down.* Ask students to relate the meanings of these word parts to the word hydrolysis. Remind students that during hydrolysis polymers are broken down by the addition of water. L2 ELL

GLENCOE TECHNOLOGY

VIDEODISC
The Secret of Life
Monosaccharide

Disaccharide

Portfolio

Planning

Logical-Mathematical Have students make a daily meal plan that contains very low levels of lipids. L2 ELL P

TechPrep

Visual-Spatial Have the students prepare a chart of the foods they had for breakfast and lunch. They should list the organic ingredients (carbohydrates, lipids, proteins, and nucleic acids) in each food they ate. L2

Portfolio

Exploring Nutrients

Interpersonal Have groups of students research and prepare a presentation on one of the following: sugars and other nutritive sweeteners in processed foods, cholesterol in the diet, saturated and unsaturated fats in the diet, or the functions of proteins such as keratin, actin, myosin, insulin, and collagen. Encourage creativity in the presentations. For example, students might enact a skit they have scripted in their portfolio. L2 COOP LEARN

Revealing Misconceptions

Students often think molecules are flat, two-dimensional structures because the formulas in books are flat. Show students structural models of various molecules so they can observe the three-dimensional appearance of molecules.

Visual Learning

Figure 6.20 Ask students to use Figure 6.20 to answer the following questions. (a) What compound serves as the backbone for lipid molecules? *glycerol* (b) How do the bonds in saturated fats differ from those in unsaturated fats? *Saturated fats have single bonds; unsaturated fats have double bonds.*

Resource Manager

Reteaching Skills Transparency 8 and Master **L1** **ELL**
Laboratory Manual, pp. 39-42 **L2**

starch but more highly branched. Cellulose is another glucose polymer that forms the cell walls of plants and gives plants structural support. Cellulose is also made of long chains of glucose units hooked together in arrangements somewhat like a chain-link fence.

The structure of lipids

If you've ever tried to lose weight, you may have wished that lipids (fats) never existed. Lipids, however, are extremely important for the proper functioning of organisms. **Lipids** are organic compounds that have a large proportion (much greater than 2 to 1) of C–H bonds and less oxygen than carbohydrates. For example, a lipid found in beef fat has the formula $C_{57}H_{110}O_6$.

Lipids are commonly called fats and oils. They are insoluble in water because their molecules are nonpolar. Recall that a nonpolar molecule is one in which there is no net electrical charge and, therefore, lipids are not attracted by water molecules. Cells use lipids for energy storage, insulation, and protective coatings. In fact, lipids are the major components of the membranes that surround all living cells. Lipids are also used in food preparation as discussed in the *BioTechnology* feature. The most common type of lipid, shown in ***Figure 6.20***, consists of three fatty acids bound to a molecule of glycerol.

The structure of proteins

Proteins are essential to all life. They provide structure for tissues and organs and carry out cell metabolism. A **protein** is a large, complex polymer

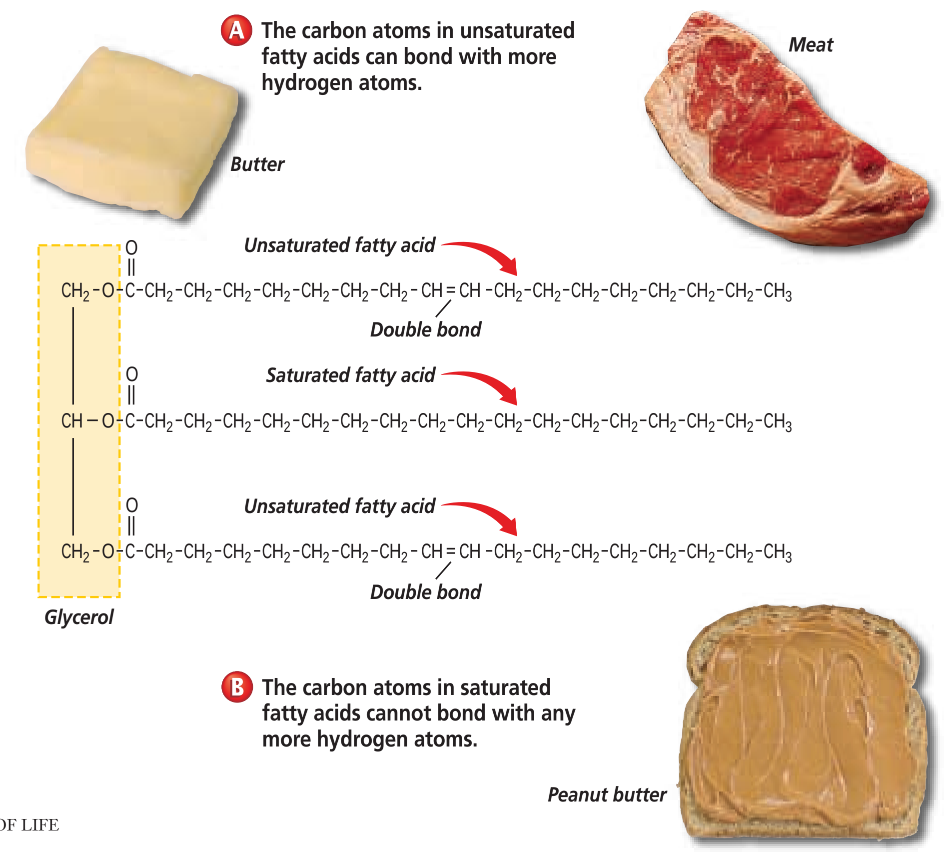


Figure 6.20
Glycerol is a three-carbon molecule that serves as a backbone for the lipid molecule. Attached to the glycerol are three fatty acids.

Figure 6.21
Each amino acid contains a central carbon atom to which are attached a carboxyl group, a hydrogen atom, an amino group ($-NH_2$), and a group (–R) that makes each amino acid different (a). Amino acids are linked together by peptide bands (b).

composed of carbon, hydrogen, oxygen, nitrogen, and usually sulfur. The basic building blocks of proteins are called **amino acids**, shown in ***Figure 6.21a.*** There are 20 common amino acids. These 20 building blocks, in various combinations, make literally thousands of proteins. Therefore, proteins come in a large variety of shapes and sizes. In fact, proteins vary more in structure than any other class of organic molecules.

Amino acids are linked together when an –H from one amino acid and an –OH group from another amino acid are removed to form a water molecule. The covalent bond formed between the amino acids, like the bond labeled in ***Figure 6.21b,*** is called a **peptide bond.** The number and order of amino acids in protein chains determine the kind of protein.

Many proteins consist of two or more amino acid chains that are held together by hydrogen bonds.

Proteins are the building blocks of many structural components of organisms, as illustrated in ***Figure 6.22.*** Proteins are also important in the contracting of muscle tissue, transporting oxygen in the bloodstream, providing immunity, regulating other proteins, and carrying out chemical reactions.

Enzymes are important proteins found in living things. An **enzyme** is a protein that changes the rate of a chemical reaction. In some cases,

Figure 6.22
Proteins make up much of the structure of organisms, such as hair, fingernails, horns, and hoofs.

Enrichment

Intrapersonal Have students research the differences in the structures of starch, glycogen, and cellulose to determine how there can be more than one polymer of glucose. **L3**

Using an Analogy

To increase understanding of how only 20 amino acids can create such a variety of proteins, relate the 20 naturally occurring amino acids to the letters of the alphabet. Elicit from students why the letters of the alphabet can be used to create such a large number of words. Relate this phenomenon to how a similar number of amino acids can create so many different proteins.

The BioLab at the end of the chapter can be used at this point in the lesson. INVESTIGATE BioLab

GLENCOE TECHNOLOGY

CD-ROM
Biology: The Dynamics of Life
Animation: *Enzyme Action*
Disc 1

Alternative Lab

What fruits contain enzymes that act on protein?

Purpose
Students will investigate the effect of the enzyme bromelin on gelatin.

Safety Precautions
Remind students to use caution with the knife.

Preparation
One pineapple should be enough for 20 students working in groups of four. A 6-ounce box of gelatin makes enough for 2 groups. Make gelatin and pour 100 mL into each paper cup. Use hot/cold cups large enough to hold 200 mL.

Materials
paper cups (4) with gelatin, fresh pineapple, knife, waxed paper, canned chunk pineapple, refrigerator, grapes or orange sections

Procedure
Give students the following directions.
1. Number the cups 1 to 4.
2. Select 3 chunks of canned pineapple. Cut 3 chunks of fresh pineapple the same size as the canned chunks. Cut 3 grapes in half, or choose three orange slices. Set these aside on waxed paper.
3. Add the following to each cup. Make sure the fruits are submerged.
   Cup 1—nothing
   Cup 2—canned pineapple chunks
   Cup 3—fresh pineapple chunks
   Cup 4—grape halves or orange slices
4. Set cups in the refrigerator. Check the cups at the end of the period.

Expected Results
Students should observe that the gelatin to which the fresh pineapple was added remained liquefied.

Analysis
1. What was the purpose of cup 1? *Control*
2. Gelatin is a protein. Bromelin is a protein-digesting enzyme. What happened to the bromelin in the canned pineapple? *It was destroyed by heat during the canning process.*

Assessment

Knowledge Ask students this question: Based on this activity, what can you conclude about which fruits have enzymes that act on protein? Use the Performance Task Assessment List for Analyzing the Data in **PASC,** p. 27. **L2**

INSIDE STORY

Purpose
Students will study the way enzymes function in a reaction.

Teaching Strategy
■ Ask students to make an analogy of a lock and key to how enzymes function. Students should also describe where the analogy fails. Even though the lock and key fit together specifically, the lock does not change shape when the key fits in the keyhole. L2

Visual Learning
Visual-Spatial Show a computerized video sequence of lysozyme activity in a cell.

Critical Thinking
The enzyme is not changed by the reaction. Once it releases the substrate, the enzyme can bind to another substrate. This process can be repeated over and over.

3 Assess

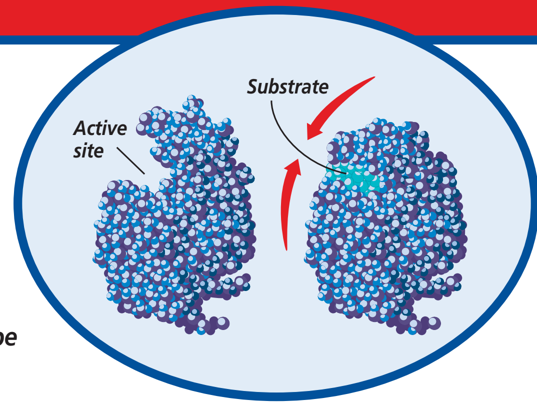
Check for Understanding
Visual-Spatial Use flash cards containing the names of monomers on one side and the corresponding polymer on the other side. First, show students the polymer name (e.g., protein) and then have them respond with the appropriate monomer name (amino acid), and vice versa. L1 ELL

Resource Manager
Reinforcement and Study Guide, p. 28 L2
Content Mastery, pp. 31, 29-32 L1
Laboratory Manual, pp. 43-46 L2

INSIDE STORY

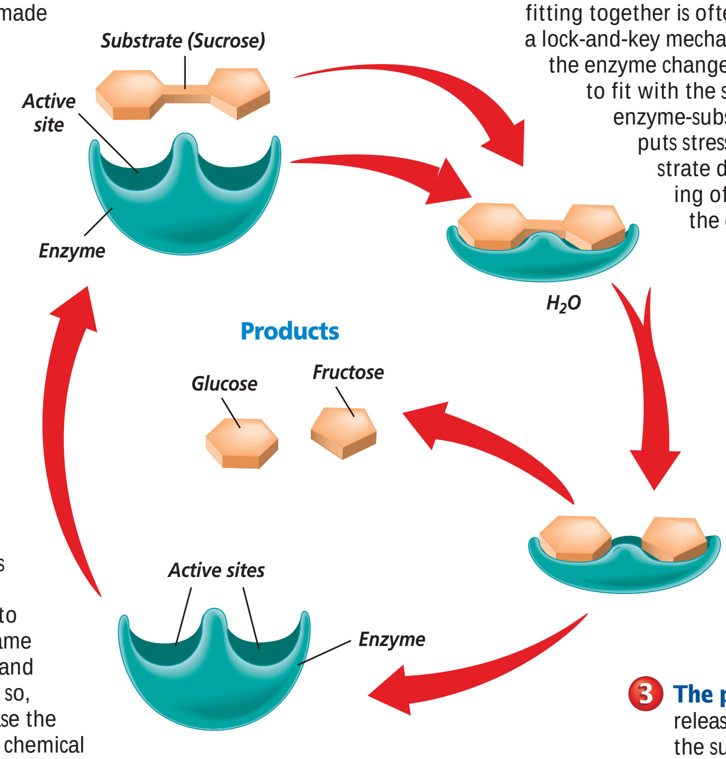
Action of Enzymes

An enzyme enables molecules, called substrates, to undergo a chemical change to form new substances, called products. The enzyme works due to an area on its surface that fits the shape of the substrate, called an active site. When the substrate fits the active site, it causes the enzyme to alter its shape slightly as shown below.



Lysozyme structure

Critical Thinking *How can an enzyme participate over and over in chemical reactions?*



1 **Enzymes** act on specific substrates, such as sucrose, a disaccharide made up of glucose and fructose bonded together.

2 **Each substrate** fits into an area of the enzyme called the active site. This fitting together is often compared to a lock-and-key mechanism. However, the enzyme changes shape a little to fit with the substrate. The enzyme-substrate complex puts stress on the substrate due to the binding of the substrate to the enzyme.

3 **The products** are released; in this case the sucrose bonds are hydrolyzed, releasing glucose and fructose.

4 **After the reaction,** the enzyme released is in its original shape and can go on to carry out the same reaction again and again. In doing so, enzymes increase the speed at which chemical reactions occur without being altered themselves by the reaction.

enzymes increase the speed of reactions that would otherwise occur so slowly you might think they wouldn't occur at all.

Enzymes are involved in nearly all metabolic processes. They speed the reactions in digestion of food. Enzymes also affect synthesis of molecules, and storage and release of energy. How do enzymes act like a lock and key to facilitate chemical reactions within a cell? Read the *Inside Story* to find out. The *BioLab* at the end of this chapter also experiments with enzymes.

The structure of nucleic acids

Nucleic acids are another important type of organic compound that is necessary for life. A **nucleic acid** (noo KLAY ihk) is a complex macromolecule that stores cellular information in the form of a code. Nucleic acids are polymers made of smaller subunits called **nucleotides.**

Nucleotides consist of carbon, hydrogen, oxygen, nitrogen, and phosphorus atoms arranged in three groups—a base, a simple sugar, and a phosphate group—as shown in ***Figure 6.23.*** You have probably heard of the nucleic acid DNA, which stands for deoxyribonucleic acid. DNA is the master copy of an organism's information code. The information coded in DNA contains the instructions used to form all of an organism's enzymes and structural proteins. Thus, DNA forms the genetic code that determines how an organism looks and acts. DNA's instructions are passed on every time a cell divides and from one generation of an organism to the next.

Another important nucleic acid is RNA, which stands for ribonucleic acid. RNA is a nucleic acid that forms a copy of DNA for use in making proteins. The chemical differences between RNA and DNA are minor but important. A later chapter discusses how DNA and RNA work together to produce proteins.

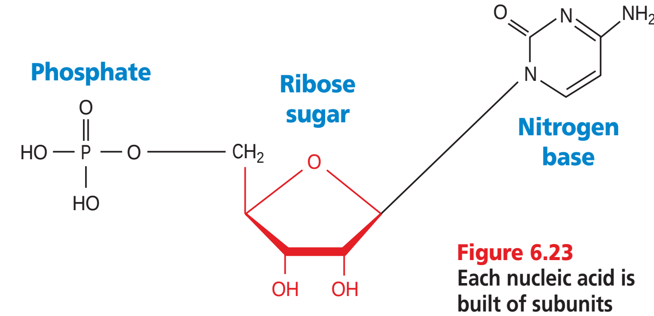


Figure 6.23
Each nucleic acid is built of subunits called nucleotides that are formed from a sugar molecule bonded to a phosphate group and a nitrogen base.

CD-ROM
View an animation of enzyme action in the Presentation Builder of the Interactive CD-ROM.

Section Assessment

Understanding Main Ideas
1. List three important functions of lipids in living organisms.
2. Describe the process by which polymers in living things are formed from smaller molecules.
3. How does a monosaccharide differ from a disaccharide?

Thinking Critically
4. Enzymes are proteins that facilitate chemical reactions. Based on your knowledge of enzymes, what might the result be if one particular enzyme malfunctioned or was not present?

SKILL REVIEW
5. **Making and Using Tables** Make a table comparing polysaccharides, lipids, proteins, and nucleic acids. List these four types of biological substances in the first column. In the next two columns, list the subunits that make up each substance and the functions of each in organisms. In the last column, provide some examples of each from the chapter. For more help, refer to *Organizing Information* in the **Skill Handbook.**

Reteach
The concept of large polymers being composed of repeating units of monomers can be reinforced by having students list items that are composed of smaller units, such as beads making up a necklace, chain links, jigsaw puzzle pieces, or letters making up words. L1 ELL

Extension
Linguistic Encourage above-level students to read *The Double Helix* by James Watson (Atheneum, 1968), which tells the story of the discovery of the DNA structure. L3

Assessment
Knowledge Prepare a handout showing structural formulas for lipids, proteins, carbohydrates, and nucleic acids. Ask students to identify the type of organic compound shown in each diagram. L2

4 Close

Discussion
Ask students to explain the differences between saturated and unsaturated fats. *Saturated fats are composed of lipids containing fatty acids with only single bonds. Unsaturated fats are composed of fatty acid chains of carbon with double bonds.* L2

GLENCOE TECHNOLOGY

VIDEODISC
The Infinite Voyage
The Future of the Past
Winterthur Museum: New Cleaning Techniques of Old Paintings (Ch. 5)
6 min.

VIDEODISC
The Secret of Life
Structure of DNA

Section Assessment

1. long-term energy storage, insulation, protective coatings
2. Polymers form when one monomer loses an H^+ ion and another loses an OH^- to form water. A covalent bond forms between the monomers.
3. A disaccharide is made of two simple sugars called monosaccharides.
4. The chemical reaction would proceed extremely slowly.
5. Subunits and functions: polysaccharides, monosaccharides—for energy storage and structural components; lipids, glycerol, and fatty acids—for long-term energy storage; proteins, amino acids—structure and enzymes; nucleic acids, nucleotides—store information in cells. Examples: polysaccharides—starch, glycogen, and cellulose; lipids—animal fats and vegetable oils; proteins—muscle proteins, immunity proteins, enzymes; nucleic acids—DNA and RNA.

DESIGN YOUR OWN BioLab

Time Allotment
One class period

Process Skills
form a hypothesis, design an experiment, interpret data, recognize cause and effect

Safety Precautions
Students should wear aprons and safety goggles. Remind students to use caution with heat sources and handle glassware with tongs.

PREPARATION

- Obtain potatoes, knives, hydrogen peroxide, and waxed paper.

Alternative Materials
Pieces of raw liver can be used instead of potato.

Possible Hypotheses
- If temperatures are very high or very low, the enzymes will be deactivated.
- If the temperature is raised, the speed at which the enzyme will work will increase.

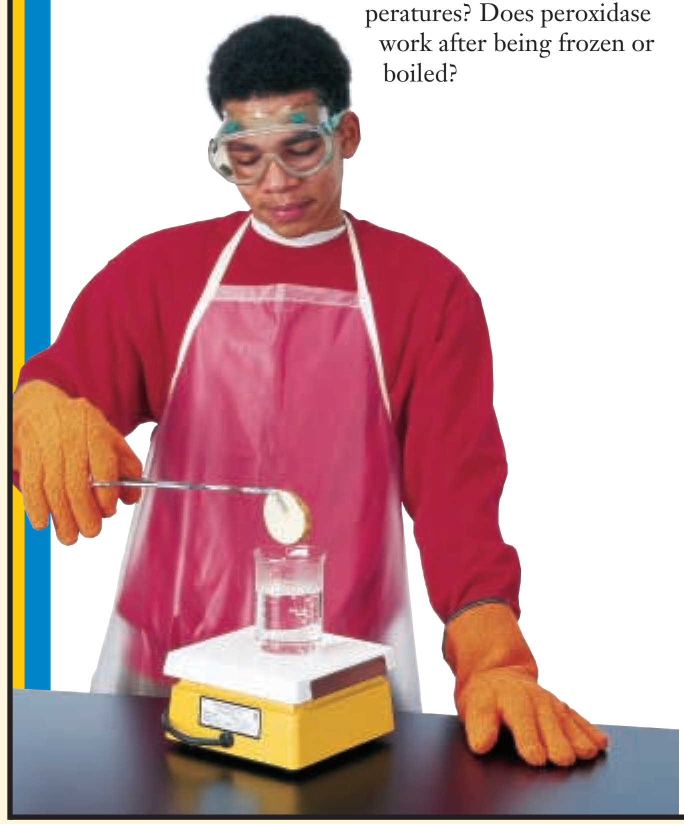
Resource Manager
BioLab and MiniLab Worksheets, p. 29 L2

DESIGN YOUR OWN BioLab

Does temperature affect an enzyme reaction?

The compound hydrogen peroxide, H_2O_2, is a by-product of metabolic reactions in most living things. However, hydrogen peroxide is damaging to delicate molecules inside cells. As a result, nearly all organisms contain the enzyme peroxidase, which breaks down H_2O_2 as it is formed. Potatoes are one source of peroxidase. Peroxidase speeds up the breakdown of hydrogen peroxide into water and gaseous oxygen. This reaction can be detected by observing the oxygen bubbles generated.

PREPARATION



Problem
Does the enzyme peroxidase work in cold temperatures? Does peroxidase work better at higher temperatures? Does peroxidase work after being frozen or boiled?

Hypotheses
Make a hypothesis regarding how you think temperature will affect the rate at which the enzyme peroxidase breaks down hydrogen peroxide. Consider both low and high temperatures.

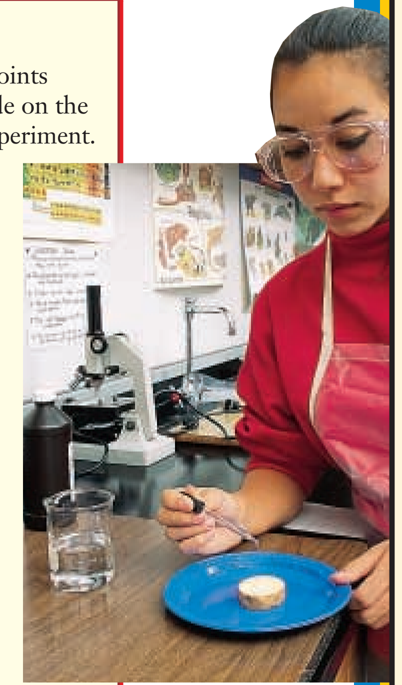
Objectives
In this BioLab, you will:
- **Observe** the activity of an enzyme.
- **Compare** the activity of the enzyme at various temperatures.

Possible Materials
clock or timer
400-mL beaker
kitchen knife
tongs or large forceps
5-mm thick potato slices
3% hydrogen peroxide
ice
hot plate
waxed paper
thermometer

Safety Precautions
Be sure to wash your hands before and after handling the lab materials. Always wear goggles in the lab.

Skill Handbook
Use the **Skill Handbook** if you need additional help with this lab.

PLAN THE EXPERIMENT



1. Decide on a way to test your group's hypothesis. Keep the available materials in mind.
2. When testing the activity of the enzyme at a certain temperature, consider the length of time it will take for the potato to reach that temperature, and how the temperature will be measured.
3. To test for peroxidase activity, add 1 drop of hydrogen peroxide to the potato slice and observe what happens.
4. When heating a thin potato slice, first place it in a small amount of water in a beaker. Then heat the beaker slowly so that the temperature of the water and the temperature of the slice are always the same. Try to make observations at several temperatures between 10°C and 100°C.

Check the Plan
Discuss the following points with other groups to decide on the final procedure for your experiment.
1. What data will you collect? How will you record them?
2. What factors should be controlled?
3. What temperatures will you test?
4. How will you achieve those temperatures?
5. ***Make sure your teacher has approved your experimental plan before you proceed further.***
6. Carry out your experiment.
CAUTION: ***Be careful with chemicals and heat. Wash hands after lab.***

ANALYZE AND CONCLUDE

1. **Checking Your Hypothesis** Do your data support or reject your hypothesis? Explain your results.
2. **Analyzing Data** At what temperature did peroxidase work best?
3. **Identifying Variables** What factors did you need to control in your tests?
4. **Recognizing Cause and Effect** If you've ever used hydrogen peroxide as an antiseptic to treat a cut or scrape, you know that it foams as soon as it touches an open wound. How can you account for this observation?

Going Further
Changing Variables To carry this experiment further, you may wish to use hydrogen peroxide to test for the presence of peroxidase in other materials, such as cut pieces of different vegetables. Also, test raw beef and diced bits of raw liver.

interNET CONNECTION To find out more about enzymes, visit the Glencoe Science Web Site. www.glencoe.com/sec/science

PLAN THE EXPERIMENT

Teaching Strategies
- Discuss the factors that might affect the rate of a reaction controlled by an enzyme.
- Students who cool the potato to low temperatures should be sure to run the test while the potato is still cool.
- Allow groups to discuss how their results differed when different experimental procedures were used.

Possible Procedures
- Students may place a piece of potato on ice for 5 minutes, boil a second piece for 5 minutes, and allow a third piece of potato to sit at room temperature for 5 minutes. Each potato will then be tested for enzyme activity.

Data and Observations
Cooling will not deactivate the enzymes but can slow the overall reaction. Potato slices heated over 70°C will not generate oxygen bubbles.

DESIGN YOUR OWN BioLab

ANALYZE AND CONCLUDE

1. Students should explain whether their data support or reject their hypotheses.
2. Between 20°C–50°C
3. Answers may include the amount of time each potato was exposed to the temperature, the sizes of the potato slices, and the amount of peroxide added.
4. Human tissue contains peroxidase, so the hydrogen peroxide is broken down and releases oxygen.

Error Analysis
Advise students that potato slices must reach the desired temperature they are testing, which will take time. Samples need to be removed and observed carefully for bubbles.

Assessment
Portfolio In their portfolios, have students summarize the results, especially the cold treatment. Discuss how results differed between cool pieces tested immediately and those allowed to warm to room temperature. Use the Performance Task Assessment List for Evaluating a Hypothesis in **PASC**, p. 31.

Going Further
Logical-Mathematical Ask students why vegetables are boiled for a short time before freezing. *One reason is that boiling inactivates enzymes that begin to break down the other molecules in the vegetables.*

BIO Technology

Purpose
Students learn about the molecular structure of dietary fats and fat substitutes. They also learn about some of the health effects that can result from the consumption of processed foods.

Background
Olestra is made by Proctor & Gamble and has the trade name Olean™. Olestra prevents the absorption of fat-soluble nutrients because of its large number of fatty acid molecules. The nutrients are absorbed by the Olestra molecules, and because these are not digested, neither are the nutrients.

Teaching Strategies
- On the chalkboard, draw a diagram of a sucrose molecule, a glycerol molecule, and a fatty acid molecule. Point out that all are formed from carbon, hydrogen, and oxygen atoms. Simple diagrams that use letter symbols for each atom and straight lines to signify chemical bonds can be found in an introductory chemistry textbook.

Investigating the Technology
1. Olestra contributes fewer calories and fats, which is helpful to people who are watching their weight or need to limit fats because of cholesterol problems or heart disease. But Olestra also prevents the body from obtaining certain nutrients from food, which could have negative health consequences. Fats are an essential part of a healthy diet, so replacing all fats with fat substitutes could present a health risk.
2. To conduct a "blind" tasting, have someone who is not participating in the test put a sample of each product in a separate container and give it an identifying letter or number. Tasters are not allowed to see the product packages or learn whether each sample contains true fats or fat substitutes until after they have recorded their taste preferences. **CAUTION:** ***Advise students who have had adverse reactions to Olestra not to participate in the blind taste test.***

BIO Technology

Are fake fats for real?

Most of us love snacks like chips, cookies, candy, fries, and ice cream. But these foods are typically high in fat, and most of us also realize that limiting our consumption of fat is one of the keys to a healthy lifestyle.

In 1996, the Federal Food and Drug Administration (FDA) approved the use of a new fat substitute called Olestra. Other fat substitutes may contain fewer calories than fat, but they break down when exposed to high temperatures. Olestra can withstand the high temperatures needed to produce fried foods like potato chips.

If it isn't fat, what is it? Most fat substitutes are molecules that are similar to fat but do not have fat's high calorie content. The oldest fat substitutes are based on carbohydrates and are used in salad dressings, dips, spreads, candy, and other foods.

Protein-based fat substitutes are also common. The proteins go through a process called microparticulation, in which they are formed into microscopic round particles. This round shape gives the substances a pleasing smoothness. Protein-based fat substitutes can be used in some cooked foods, but not fried foods.

A fat substitute made from fat Unlike other fat substitutes, Olestra is based on actual fat molecules. It is made by surrounding a sugar molecule, sucrose, with six to eight fatty acid molecules. Naturally occurring dietary fats are made of a glycerol molecule with three fatty acids attached. Because Olestra contains many fatty acid molecules, the digestive system cannot break it down and it passes through the body undigested.

Olestra does have drawbacks. As Olestra passes through the digestive system, it can absorb and carry some fat-soluble vitamins and nutrients. These include vitamins A and E, plus beta carotene, which has been shown to help prevent some forms of cancer.

Fat substitutes will not replace natural fats entirely, but products like Olestra give food scientists some options when they are developing reduced-fat and reduced-calorie foods.

Snack foods made with fat substitutes

Investigating the Technology
1. What are some of the pros and cons of including foods made with Olestra in your diet? Do you think it's a good idea to eat foods made only with fat substitutes rather than true fats? Why or why not?
2. Set up a blind taste test to compare chips or other snack foods made with naturally occurring fats to snacks made with different fat substitutes. Record class preferences. How many tasters could tell the difference between "fake" fats and "real" fats?

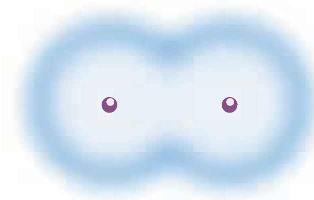
interNET CONNECTION For more information on food technology, visit the Glencoe Science Web Site. **www.glencoe.com/sec/science**

Going Further
Have students conduct research to find out which nutrients Olestra prevents the body from absorbing and why they are essential. Encourage students to find out about the long-term health effects of Olestra and other fat substitutes. L3

Chapter 6 Assessment

Summary

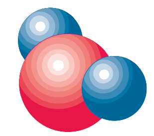
Section 6.1
Atoms and Their Interactions



Main Ideas
- Atoms are the basic building blocks of all matter.
- Atoms consist of a nucleus containing protons and neutrons. The positively charged nucleus is surrounded by a cloud of rapidly moving, negatively charged electrons.
  - Atoms become stable by bonding to other atoms through covalent or ionic bonds.
  - Components of mixtures retain their properties—components of solutions do not.

Vocabulary
acid (p. 154)
atom (p. 146)
base (p. 154)
compound (p. 149)
covalent bond (p. 150)
element (p. 145)
ion (p. 151)
ionic bond (p. 151)
isotope (p. 148)
metabolism (p. 151)
mixture (p. 152)
molecule (p. 150)
nucleus (p. 147)
pH (p. 154)
solution (p. 153)

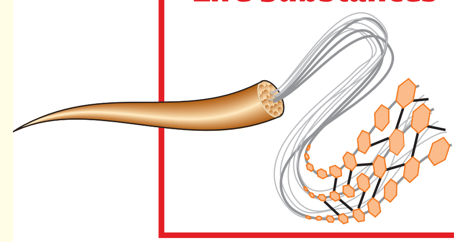
Section 6.2
Water and Diffusion



Main Ideas
- Water is the most abundant compound in living things.
- Water is an excellent solvent due to the polar property of its molecules.
- Particles of matter are in constant motion.
- Diffusion occurs from areas of higher concentration to areas of lower concentration.

Vocabulary
diffusion (p. 159)
dynamic equilibrium (p. 160)
hydrogen bond (p. 157)
polar molecule (p. 156)

Section 6.3
Life Substances



Main Ideas
- All organic compounds contain carbon atoms.
- There are four principal types of organic compounds that make up living things: carbohydrates, lipids, proteins, and nucleic acids.

Vocabulary
amino acid (p. 165)
carbohydrate (p. 162)
enzyme (p. 165)
isomer (p. 162)
lipid (p. 164)
nucleic acid (p. 167)
nucleotide (p. 167)
peptide bond (p. 165)
polymer (p. 162)
protein (p. 164)

Understanding Main Ideas

1. What are the basic building blocks of all matter?
   a. electrons
   b. protons
   c. atoms
   d. molecules
2. Which feature of water explains why water has high surface tension?
   a. water diffuses into cells
   b. water's resistance to temperature changes
   c. water is a polar molecule
   d. water expands when it freezes

Main Ideas
Summary statements can be used by students to review the major concepts of the chapter.

Using the Vocabulary
To reinforce chapter vocabulary, use the Content Mastery Booklet and the activities in the Interactive Tutor for Biology: The Dynamics of Life on the Glencoe Science Web Site. **www.glencoe.com/sec/science**

THE PRINCETON REVIEW *All Chapter Assessment questions and answers have been validated for accuracy and suitability by The Princeton Review.*

Understanding Main Ideas
1. c
2. c

GLENCOE TECHNOLOGY
VIDEOTAPE
MindJogger Videoquizzes
Chapter 6: *The Chemistry of Life*
Have students work in groups as they play the videoquiz game to review key chapter concepts.

Resource Manager
Chapter Assessment, pp. 31-36
MindJogger Videoquizzes
Computer Test Bank
BDOL Interactive CD-ROM, Chapter 6 quiz

3. a
4. c
5. d
6. d
7. d
8. c
9. d
10. d
11. speeds
12. 20
13. covalent
14. 2
15. hydrogen; oxygen
16. active site
17. elements
18. peptide; protein
19. high; low
20. hydrogen; oxygen

Applying Main Ideas

21. The underlying energy level is a filled level.
22. Water is a polar molecule; it will not attract the nonpolar grease.
23. Carbon is the building block element of the four basic substances (carbohydrates, lipids, proteins, and nucleic acids) found in all known living organisms.
24. The substance was a compound because two new substances were formed by the chemical reaction.

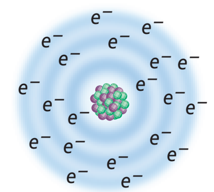
3. Which of the following describes an isotope of the commonly occurring oxygen atom which has 8 electrons, 8 protons, and 8 neutrons?
   a. 8 electrons, 8 protons, and 9 neutrons
   b. 7 electrons, 8 protons, and 8 neutrons
   c. 8 electrons, 7 protons, and 8 neutrons
   d. 7 electrons, 7 protons, and 8 neutrons
4. Which of the following will form a solution?
   a. sand and water c. salt and water
   b. oil and water d. salt and sand
5. Which of the following applies to a water molecule?
   a. Water is a nonpolar molecule.
   b. The atoms in water are bonded by ionic bonds.
   c. The weak bond between two water molecules is a covalent bond.
   d. Water molecules have a negatively charged end and a positively charged end.
6. Which of the following carbohydrates is a polysaccharide?
   a. glucose c. sucrose
   b. fructose d. starch
7. Which of the following pairs is unrelated?
   a. sugar—carbohydrate
   b. fat—lipid
   c. amino acid—protein
   d. starch—nucleic acid
8. An acid is any substance that forms _______ in water.
   a. hydroxide ions c. hydrogen ions
   b. oxygen ions d. sodium ions
9. Which of these is NOT made up of proteins?
   a. hair c. fingernails
   b. enzymes d. cellulose

Test-Taking Tip

The Princeton Review

When Eliminating, Cross It Out
Cross out choices you've eliminated with your pencil. List the answer choice letters on the scratch paper and cross them out there. You'll stop yourself from choosing an answer you've mentally eliminated.

10. Which of the following is NOT a smaller subunit of a nucleotide?
    a. phosphate c. ribose sugar
    b. nitrogen base d. glycerol
11. An enzyme _______ chemical reactions.
12. A calcium atom has 20 protons and _______ electrons.



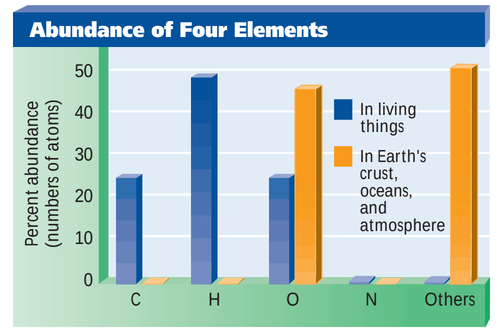
13. A _______ bond involves sharing of electrons.
14. The first energy level of an atom holds _______ electrons; the second energy level holds 8 electrons.
15. In a water molecule, each _______ atom shares one electron with the single _______ atom.
16. A substrate fits into an area of an enzyme called the _______.
17. Hydrogen, chlorine, and sodium are examples of _______.
18. Long chains of amino acids connected to each other by a _______ bond form a _______.
19. Diffusion is the process in which molecules move from a _______ concentration to a _______ concentration.
20. The positively charged _______ atoms of one water molecule attract the negatively charged _______ atom of another water molecule to form a hydrogen bond.

Applying Main Ideas

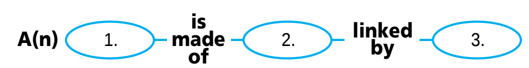
21. A magnesium atom has 12 electrons. When it reacts, it usually loses two electrons. How does this loss make magnesium more stable?
22. Explain why water and a sponge would not be effective in cleaning up a grease spill.
23. Explain why carbon is the most critical element to living things.
24. If heating a white substance produces a vapor and black material, how do you know the substance was not an element?

Thinking Critically

25. **Interpreting Data** The following graph compares the abundance of four elements in living things to their abundance in Earth's crust, oceans, and atmosphere. Which element is the most abundant in organisms? What can you say about the general composition of living things compared to nonliving matter near Earth's surface?



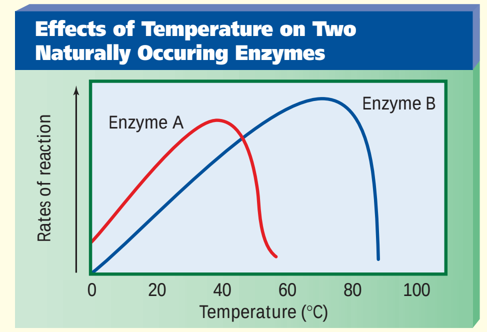
26. **Designing an Experiment** The enzyme peroxidase triggers the breakdown of hydrogen peroxide to form water and oxygen gas. Design an experiment that measures the rate of the reaction.
27. **Concept Mapping** Complete the concept map by using the following vocabulary terms: protein, amino acid, peptide bond.



CD-ROM
For additional review, use the assessment options for this chapter found on the ***Biology: The Dynamics of Life Interactive CD-ROM*** and on the Glencoe Science Web Site.
www.glencoe.com/sec/science

Assessing Knowledge & Skills

Two students were studying the effect of temperature on two naturally occurring enzymes. The graph below summarizes their data.



Using a Graph Study the graph and answer the following questions.

1. At what temperature does the maximum activity of enzyme B occur?
   a. 0° c. 60°
   b. 35° d. 70°
2. At what temperature do both enzymes have an equal rate of reaction?
   a. 10° c. 45°
   b. 20° d. 60°
3. Which of the following descriptions best explains the patterns of temperature effects shown on this graph?
   a. Each enzyme has its own optimal temperature range.
   b. Both enzymes have the same optimal temperature ranges.
   c. Each enzyme will function at room temperature.
   d. Both enzymes are inactivated by freezing temperatures.
4. **Designing an Experiment** Design an experiment to test the optimal pH of enzyme B.

Thinking Critically

25. Hydrogen is the most abundant element in organisms. Living things contain much more hydrogen and carbon, about half the oxygen, and similar amounts of nitrogen when compared with nonliving substances.
26. Possible answers might include counting the bubbles given off or collecting and measuring the volume of oxygen given off.
27. 1. Protein; 2. Amino acids; 3. Peptide bonds

Assessing Knowledge & Skills

1. d
2. c
3. a
4. Place an equal amount of enzyme and substrate at different pH levels and assess the rate of the reaction at each pH.